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ORIGINAL ARTICLES.

I.—Cirripedes from the Trimmingham Chalk and other localities in Norfolk.

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(WITH FORTY-ONE TEXT-FIGURES.)

SOME years since Mr. Reginald M. Brydone, F.G.S., placed in my hands a number of fossil Cirripedes from the Chalk of Trimmingham, Norfolk,[1] with the request that I would describe them. Others have lately been sent to me by Mr. Clement Reid, F.R.S., from his private collection and from the Geological Survey Museum; also a set of Chalk Lepadidæ from Dr. Arthur Rowe, F.G.S., of Margate, collected by him in the vicinity of Norwich. I now take up the study of these too long neglected specimens.

1. Brachylepas cretacea, H. Woodw., 1901.

Pyrgoma cretacea, H. Woodw., 1868: Geol. Mag., Vol. V, p. 258, Pl. XIV, Figs. 1, 2.

Pollicipes cancellatus, Marsson, 1880: Cirrip. d. Weiss. Schreib. Kreide d. Rügen, p. 24, Tat. ii, fig. 7*a*.

Brachylepas cretacea, H. Woodw., 1901: Geol. Mag., Dec. IV, Vol. VIII, p. 145, Pl. VIII, Figs. 3–5.

In a contribution to "British Fossil Crustacea," made in 1868,[2] I figured and described a portion of a Cirripede from the Chalk of Norwich under the name of *Pyrgoma cretacea*.

No further notice of this species occurred until 1901, when Dr. Arthur Rowe kindly placed in my hands a specimen obtained by him from the Norwich Chalk, which threw a most important light on this interesting fossil, proving it to be quite distinct from the genus *Pyrgoma*, and worthy to form a new genus, having characters which might serve as a connecting link between the more ancient Pedunculata and the more modern Operculata.[3] A reference to this paper will show that *Brachylepas* had a series of three or four verticillate whorls of small scale-like imbricated plates, forming the base of the capitulum supporting the rostrum and carina

[1] For an account of this interesting deposit see "The Stratigraphy and Fauna of the Trimmingham Chalk," by R. M. Brydone, 1900, 8vo, pp. 16, with diagrams; Dulau & Co., price 1*s*. (separately published). Also "Further Notes on the Trimmingham Chalk, Norfolk," by R. M. Brydone, F.G.S., Geol. Mag., 1906, January, pp. 13–22, Plates II and III; February, pp. 72–78, Plates IV and V; March, pp. 124–131, Plates VIII and IX; and July, pp. 289–300.

[2] Geol. Mag., 1868, pp. 258, 259, Pl. XIV, Figs. 1, 2.

[3] Geol. Mag., Dec. IV, Vol. VIII (1901), pp. 145–152, Pl. VIII, Figs. 3, 4.

(the latera, scuta, and terga being displaced, but diagrammatically restored in the woodcut (Fig. 3, given on p. 149). Later on Dr. Rowe contributed another example from the Chalk of Whitway Pit, South Dorset, from the *Bel. mucronata* zone (see GEOL. MAG., 1901, p. 528). He also subsequently sent me, among other specimens, eight carinæ and rostra of *Brachylepas cretacea*, together with detached scales, etc., from the Chalk of Edward's Pit, Mousehold, Norwich. I am now able to record *Brachylepas cretacea* as having been found by Mr. Brydone in the Chalk Bluffs of Trimmingham. In his collection sent to me is a single, very well preserved carina, which Mr. Brydone transmitted some years before with other Trimmingham fossils to Dr. Wilhelm Deecke (Professor of Geology and Palæontology in the Royal University of Greifswald, Prussian Germany), who at once identified it as *Pollicipes cancellatus*, Marsson[1] (1880). A careful comparison of Mr. Brydone's specimen with Dr. Marsson's figure on the one hand and with the long series of specimens obtained by Dr. Rowe from the Chalk of Catton, near Norwich, leaves no doubt in my mind that *P. cancellatus*, Marsson, is identical with *Brachylepas* (*Pyrgoma*) *cretacea*, H. Woodw., 1868, so that *P. cancellatus* must be treated as a synonym of *Br. cretacea*. Mr. Brydone writes me: "I never found any more such perfectly preserved valves of *Br. cretacea* at Trimmingham, nor any associated valves, but I must have at least a dozen or more indifferently well preserved examples in my collection, so that 'relatively common' is a fair statement in regard to this species at Trimmingham."

Distribution of *Brachylepas cretacea*: This species has been found in the Upper Chalk (zone of *Bel. mucronata*), Whitway Pit, South Dorset; in the Isle of Wight; at Weybourne and Trimmingham, Norfolk; at Catton, near Norwich; and in the Chalk of Rügen.

[Before describing a new form of *Brachylepas* I desire to express my regret in having in my former paper (GEOL. MAG., 1901, pp. 145–152), quite unintentionally, overlooked a most important piece of evidence relating to this remarkable Cirripede, published in 1857, by my old friend Monsieur J. A. H. Bosquet, of Maestricht (who died in 1880). In his "Notice sur quelques Cirripèdes dans le Terrain Crétacé du Duché de Limbourg" (4to, Harlem, 1857, pp. 36, plates i–iii) the author figures and describes some 17 species; 1 of *Chthamalus*, 2 of *Verruca*, 6 of *Scalpellum*, 8 of *Pollicipes*, for which latter he retains Oken's generic name *Mitella*, discarded by Darwin.[2]

[1] See "Die Cirripedien und Ostracoden der Weissen Schreib-kreide der Insel Rügen," von Dr. Th. Marsson, in Greifswald. Mittheil. aus dem Naturwiss. Vereine von Neu-Vorpommern und Rügen in Greifswald. Redigirt von Dr. Th. Marsson, 1880, p. 24, Taf. ii, fig. 7*a*.

[2] Referring to the genus *Pollicipes*, Leach, 1817, adopted by Darwin in his "Monograph on the Fossil Cirripedia" (Pal. Soc., 1851, p. 47), that author observes: "This is one of the rare cases in which, after much deliberation and with the advice of several distinguished naturalists, I have departed from the rules of the British Association; for it will be seen that *Mitella* of Oken and *Ramphidiona* of Schumacher are both prior to *Pollicipes* of Leach; yet as the latter name is universally adopted throughout Europe and North America, and has been extensively

One of these, named by M. Bosquet *Mitella lithotryoides*, of which he describes and figures from the Chalk of Maestricht the five separated plates — viz., the carina, rostrum, sub-rostrum, scutum, and latus; the tergum is not represented (see op. cit., pp. 23–27, pl. iii, figs. 5–10)—shows, like Dr. Arthur Rowe's specimen from the

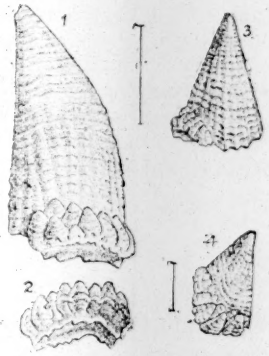


Fig. 1. *Brachylepas* (*Mitella*) *lithotryoides*, Bosq., sp. External view of left side of carina, with two or more rows of lateral scales still adherent to its base. Enlarged about twice nat. size. From the Chalk of Maestricht.
Fig. 2. Group of adherent latera viewed from the inside.
Fig. 3. The same valve as in Fig. 1 viewed dorsally. About nat. size.
Fig. 4. Sub-rostrum, showing adherent verticillate latera. About twice nat. size.

(Figs. 1–4 copied from M. Bosquet's memoir on "Cirripèdes dans Crétacé du Duché de Limbourg," 4to, 1857, Harlem, pp. 23–27, pl. iii, figs. 6*a*, *b*, *d*, and 9*a*, *c*.)

Norwich Chalk, portions of three rows of small verticillate, imbricated scale-like plates still adhering to the bases of the carina and sub-rostrum, and although not absolutely specifically identical with Dr. Rowe's *Brachylepas cretacea*, I have no hesitation in referring the Maestricht specimens of *M. lithotryoides* to the genus *Brachylepas*.[1]

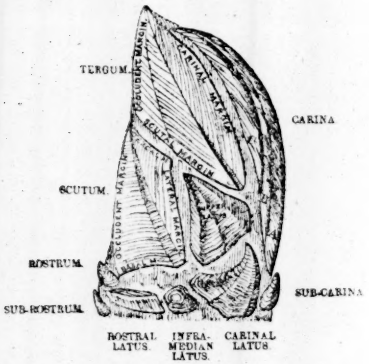
used in geological works, it has appeared to me to be as useless as hopeless to attempt any change. It may be observed that the genus *Pollicipes* was originally proposed by Sir John Hill ('History of Animals,' vol. iii, p. 170) in 1752, but as this was before the discovery of the binomial system, by the rules it is absolutely excluded as of any authority. In my opinion, under all these circumstances, it would be mere pedantry to go back to Oken's 'Lehrbuch der Naturgesch.' for the name *Mitella*,—a work little known, and displaying entire ignorance regarding the Cirripedia."

[1] I do not find any very close analogy between M. Bosquet's *Mitella lithotryoides* and the living genus *Lithotrya*, which is a burrowing Cirripede, lodged in cavities bored in calcareous rocks, shells, or corals, having the lower part of the peduncle *quite naked*, the upper margin being covered by two rows of square non-imbricate scales, followed by several rows of minute separate stellate plates, each row becoming less and less in size until they disappear almost altogether. In *M. lithotryoides* the scales are numerous, close set, and imbricated. The valves of the capitulum have a very close agreement with *Brachylepas cretacea*, H. Woodw., and, as I hope to show, also with *B.* (*Pollicipes*) *fallax*. I propose therefore, if permissible, to discard the specific name *lithotryoides*, and would suggest that of *B. Bosquetii*, in compliment to the author, as less misleading and more appropriate to the species.

As nearly all the Lepadidæ occurring in a fossil state are met with as detached valves, it will be found convenient to give here a figure of *Scalpellum* (after Darwin) in which the valves forming the capitulum are all named, and their relative position to one another when united is admirably shown (Fig. A).

The other figure given is that of the recent *Pollicipes mitella*. Darwin says of *Pollicipes*,[1] "this is the most ancient genus of the Lepadidæ and seems also to be the base of the genealogical tree; for *Pollicipes* leads, with hardly a break, by some of its species into *Scalpellum villosum*, and *Scalpellum* leads by *Oxynaspis* into *Lepas* and the allied genera; *Pollicipes mitella* is *nearer allied to the Sessile Cirripedes* than is any other pedunculated Cirripede, except perhaps *Lithotrya*, which is also closely connected with *Pollicipes*."

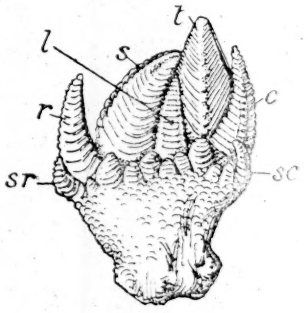
CAPITULUM.



PEDUNCLE.

FIG. A.—*Scalpellum fossula*, from the Norwich Chalk (after Darwin).

CAPITULUM.



PEDUNCLE.

FIG. B.—*Pollicipes mitella*, Linn.,[2] a living Philippine species (after Darwin).

Turrilepas and *Brachylepas* were of course unknown until a much later date. *Pollicipes mitella* certainly enables one to understand the structure of *Brachylepas* better than any other Cirripede with which I am acquainted.]

2. BRACHYLEPAS (POLLICIPES) FALLAX, Darwin, sp., 1851. (Figs. 5–24.)

Pollicipes fallax, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), pp. 75, 76, tab. iv, figs. 8*a*, *b*, 4to.

Mitella fallax, Bosquet, 1857: "Cirripèdes dans le Terrain Crétacé du Duché de Limbourg," 4to, Harlem, pp. 17–23, pl. ii, figs. 1–12; pl. iii, figs. 1, 2.

This species is well represented from the Chalk Bluffs of Trimmingham, Norfolk, and was first described by Charles Darwin in 1851 (*supra*). Darwin only figured a scutum (8*a*) and a tergum (8*b*), twice natural size. These were from the Upper Chalk of Norwich (Fitch Coll.), still preserved and identified by Mr. F. Leney

[1] Darwin, Fossil Lepadidæ: Pal. Soc. Mon., 1851, p. 48.

[2] The letters attached to the valves in *Pollicipes mitella* (Fig. B) correspond to the names on the valves in *Scalpellum* (Fig. A) placed beside it.

in the Norwich Castle Museum. See "Catalogue of Types," by F. Leney, GEOL. MAG., 1902, Crustacea, p. 226 [2153]. Darwin records the occurrence of this species from the Chalk of Maestricht, Balsberg, and Kopinge, Scania, and from the Oberer Kreidemergel (U. Chalk), Gehrden, in Hanover.

Five specimens, probably from Plauen, near Dresden (Ober-Quader), have also come into my hands, which, although of larger size, suggest very close relationship to, if not identity with, *P. fallax* of Darwin.

Mr. Brydone writes: — "The whole of the specimens of *Brachylepas fallax* obtained by me at Trimmingham were extracted from the chalk, filling a depression in the base of a large pyramidal flint, in the surface of which there are still imbedded 3 carinæ, 2 right and 2 left scuta, and a rostrum, all belonging to *B. fallax*. There are also two valves belonging to some other species imbedded

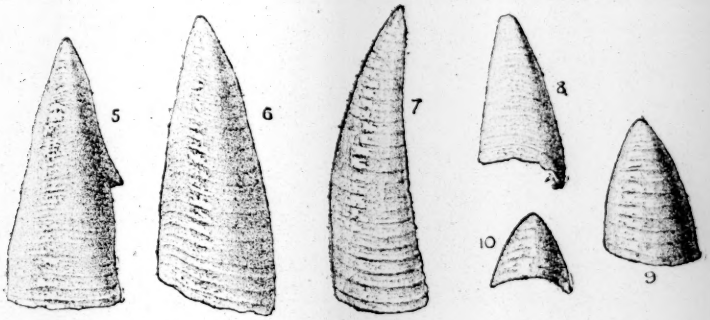


FIG. 5. *Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. External dorsal aspect of carina. All × 2 nat. size. From the Chalk of Trimmingham, Norfolk.
FIG. 6. Another specimen (same view).
FIG. 7. Right side view of Fig. 6.
FIG. 8. Rostrum, side view (of smaller individual).
FIG. 9. Rostrum of same species.
FIG. 10. Sub-rostrum of same.

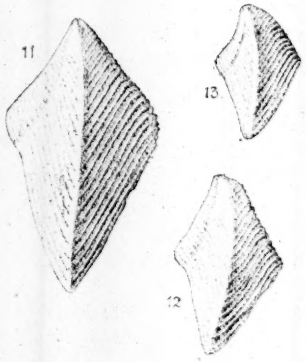
in the *side* of the flint, but otherwise no valves of any other Cirripede were found in, or in connection with, this flint. The grounds, therefore, upon which these valves are associated in one species are of a strength almost unique in the case of chalk forms. Apart from this special series of associated valves it should also be mentioned that *B. fallax* is by far the most abundant species of Cirripede in the Trimmingham Chalk, but the majority of the specimens I have met with are more or less damaged."

In M. Bosquet's memoir, we find in addition to the scutum and tergum (figured both by Bosquet and Darwin) those of the carina, rostrum, sub-carina, sub-rostrum, the upper latus, and seven of the lesser latera carefully figured and described. As these same valves occur in the Trimmingham Chalk, with scuta and terga identical with those figured by Darwin and Bosquet, and referred by them to *P.* (*Mitella*) *fallax*, I give here the description of the additional

valves which I propose to treat as belonging to the same form of Cirripede. (See Figs. 5–10.)

Carina (Figs. 5–7).—Nearly straight, semi-conical, feebly swollen in the lower part of its length; the basal border slightly excavated; the interior deeply concave, one sees that a considerable part of the summit projected freely, as does the apex of the carina and that of the rostrum also in the living *Pollicipes mitella* (see *ante*, p. 340, Fig. B, *c*, *r*; and Darwin's "Lepadidæ," Ray Society, 1851, pl. vii, fig. 3). Lines of growth, more strongly marked near the lower border, encircle the carinal valve from the base to the summit.

Sub-carina.—This valve differs but little in form from the sub-rostrum, but M. Bosquet believes it to be the sub-carina on account of its dimensions, and because he thinks its form corresponds with that of the carina; it is much more slender than the latter, and its summit is slightly inflected, and for about one-third of its length it probably projected freely.



Figs. 11–13.—Three terga of *Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. × 2 nat. size. From the Chalk of Trimmingham.

Rostrum (Figs. 8, 9).—Smaller than the carina, semicircular at the base, and more triangular in form, the apex more or less inflected, and its basal portion nearly flat, with the feeblest indication of a median longitudinal keel, the transverse lines of growth are clearly marked; deeply concave within and projecting freely at its upper part.

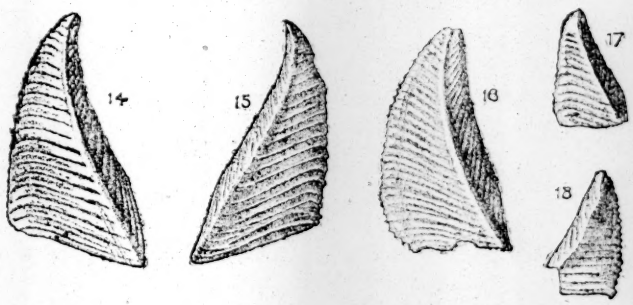
Sub-rostrum (Fig. 10).—This is much shorter and proportionally broader than the rostrum; it is slightly carinated, and the surface shows some very feeble longitudinal grooves, the basal border is very slightly excavated, and the upper part projected freely.

Description of scutum and tergum.[1]—"The valves are moderately thick; they are conspicuously marked with rather wide prominent ridges, forming the basal edges of each zone of growth; they seem in both scuta and terga most strongly developed near the occludent margins. (See Figs. 11–18.)

[1] After Darwin's monograph, p. 75.

"*Tergum* (Figs. 11–13).—Rather broad, convex; apex pointed and much curled towards the scuta; upper carinal margin unusually arched, slightly longer[1] than the lower carinal margin; there is a deep depression parallel to the occludent margin, which is itself rounded, protuberant, and considerably shorter than the scutal margin. A curved ridge projecting up above the general surface of the valve, with sloping sides, runs from the apex to the basal angle, which latter is broad and rounded;[2] the ridge runs down nearly in the middle of the valve." (Darwin, op. cit., p. 76.)

"*Scutum* (Figs. 14–18).—Almost triangular, moderately convex; occludent margin considerably arched in the upper part and bowed towards the terga; basal margin not straight, with a short portion close to the rostral angle, forming a rectangle with the occludent margin; the remaining portion, if produced, would form a rather



FIGS. 14–18.—Five scuta of *Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. × 2 nat. size. From the Chalk of Trimmingham.

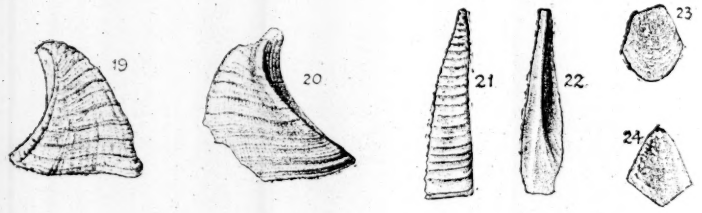
larger angle with it; hence the baso-lateral portion of the whole valve is somewhat protuberant. The tergo-lateral margin is in the upper part slightly hollowed out, and in the lower part almost straight. A very slightly curved ridge runs from the apex to the baso-lateral angle, which is broad, rounded, and not prominent; the ridge has sloping, not wall-like sides. Internally the structure of the upper part closely resembles that of *P. rigidus*. The occludent edge is thickened, broad, and flat, and is marked by lines of growth, and widens towards the apex; there is a rather deep furrow close to the tergal margin, but there is no trace of a central ridge; the deep pit for the adductor muscle lies quite close under the furrow and flat occludent edg The furrow on the tergal side is rather narrower, and a central portion of the inner occludent margin

[1] This does not hold good in a number of specimens. Thus, the upper carinal margin in four specimens measures 8, 9, 10, and 11 mm.; whilst the lower margin in the same specimens measures 8, 11, 11, and 10 mm.; so that the relative length of the margin and also the degree of curvature varies considerably.

[2] The basal angle in a number of terga of this species, instead of being broad and rounded, is narrow and rather pointed. I am, however, inclined to consider these only trivial variations and of no real specific importance.

(marked with lines of growth) here forms a slightly prominent ridge." The inner basal angle of the specimens now before me is rather more produced to an acute angle than in Darwin's figure.

Latera.—The upper pair of latera (Figs. 21, 22) are much longer than those of the series forming the lower whorls;[1] they are flat, very narrow, tapering, and acutely triangular in form, the summits being worn smooth; the rest of the exterior surface is ornamented by about twenty raised transverse ridges or periodic lines of growth, giving them a somewhat similar appearance to the ornamentation on the surface of the scutum and tergum. These lines of growth pass over the edges of the lateral borders, and are continued on the inner surface of the valve, where they curve upwards, meeting in a raised median longitudinal ridge, which is frequently prolonged to the apex of the latera. Width of larger latera 3 mm., length 13 mm.



FIGS. 19–24.—*Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. From the Chalk of Trimmingham, Norfolk.

FIGS. 19, 20. Carinal latera, or sub-carinæ. × 2 nat. size.
FIG. 21. Latera, external view. × 2 nat. size.
FIG. 22. Latera, internal view. × 2 nat. size.
FIGS. 23, 24. Sub-latera. × 3 nat. size.

Basal latera.—Two basal latera found associated with the above measure 3 mm. in length by 2 mm. in breadth; they are marked by arching striæ. (See Figs. 23, 24.)

Dimensions of separate valves of *B. fallax* from Trimmingham :—

Scuta.—There are eight examples of scuta. I give measurements of six :—

Colln.	Length in mm.	Breadth in mm.
1. R. M. Brydone	18 (apex to angle of lowest curve)	11 (greatest).
2. R. M. B.	17 (pair valve)	(injured on lat. marg.).
3. R. M. B.	10 (small specimen)	6
4. R. M. B.	8 (small specimen)	5
5. R. M. B.	8 (small specimen)	$5\frac{1}{2}$
6. Geol. Surv. Mus.	8 (specimen imperfect)	5

[1] In his description of *Mitella fallax* from the Maestricht Chalk, Mons. Bosquet says these latera are three times as long as the largest of the lower whorls and many times larger than those of the lowest and smallest series, op. cit., p. 20. On his pl. ii, figs. 7*a*, *b* (op. cit.), Bosquet figures a *latus* precisely similar to Mr. Brydone's specimen from Trimmingham, Figs. 21, 22, *supra*.

Terga.—There are ten examples of terga from Trimmingham :—

	Colln.	Length in mm.	Breadth in mm.
1.	R. M. Brydone ...	15½	10 (a perfect valve).
2*a*.	C. Reid	13 (apex lost) ...	8 (breadth perfect).
2*b*.	C. Reid	12 (base lost) ...	10 ,,
3.	R. M. B.	19 (perfect)... ...	11½ ,,
4.	R. M. B.	14 (base lost) ...	11½ ,,
5.	R. M. B.	10 (perfect)... ...	6 ,,
6.	R. M. B.	10 (perfect)... ...	6 ,,
7.	Geol. Surv. Mus. ...	13 (perfect)... ...	8½ ,,

Carina.—I assume that the larger of the conical series of valves found by Mr. Brydone associated in the hollow of a chalk flint from Trimmingham are referable to *carinæ*. They agree most closely with M. Bosquet's figures of the carina of *Mitella fallax* from the Chalk of Maestricht. The following are the dimensions of four *carinæ* and eight *rostra* :—

Carinæ.

	Colln.	Length.	Breadth at base.
1.	R. M. Brydone	20 mm.	Estimated on a straight line, 8 mm.
2.	R. M. B. ...	20 mm.	,, ,, ,, 9 mm.
3.	R. M. B. ...	13 mm.	,, ,, ,, 9 mm.
4.	R. M. B. ...	13 mm.	,, ,, ,, 8 mm. (rugose curved form).

Rostra.

	Colln.	Length.	Breadth.	
1.	R. M. Brydone ...	13 mm. (imperfect) ...	7 mm.	
2.	R. M. B.	14 ,, ...	7 ,,	
3.	R. M. B.	10 ,, ...	7 ,,	
4.	R. M. B.	10 ,, ...	6 ,,	(injured at base).
5.	R. M. B.	8 ,, ...	6 ,,	
6.	R. M. B.	5 ,, ...	6 ,,	
7.	R. M. B.	5 ,, ...	4 ,,	(sub-rostra?).
8.	R. M. B.	3 ,, ...	4 ,,	,,

Three other valves must be noticed; these are carinal latera (Figs. 19, 20). The most perfect example was found by Mr. Brydone attached to a carina of *Brachylepas* (*Pollicipes*) *fallax*, which seems good evidence of its having once formed part of the same capitulum.

Dr. Marsson,[1] in his memoir on the "Cirripedien d. Rügenschen Kreide," p. 12, taf. i, figs. 3*c*, *c'*, figures and describes a precisely similar form of plate under *Scalpellum fossula*; but I believe that our Trimmingham examples really belong to *Brachylepas fallax* (cf. Figs. 19, 20 with Marsson's taf. i, fig. 3). Dr. Marsson says: "These carinal latera are obliquely triangular, and have an arcuate carinal side, the apex (or umbo) of which has an uncinate curvature directed towards the opposite (concave) side, which presents a parietes-like margin curved at almost a right angle. This margin terminates directly underneath the umbo in a rectangular crest; the surface is marked by longitudinal parallel rib-like striæ, passing over the crest and forming underneath it, alongside the carinal

[1] "Mittheilungen aus dem Naturwissenschaftlichen Vereine von Neu-Vorpommern und Rügen in Greifswald," von Dr. Th. Marsson, xii-xviii, Berlin, 1880.

margin, a rather broad, somewhat hollow zone. The surface is marked by four or five ribs of unequal distance apart; the carinal margin is the narrowest, and is slightly curved inwards; the broadest areas have a longitudinal depression between them. (In the Trimmingham specimens these longitudinal lines are very faint indeed, the horizontal lines being the strongest.) The basal margin is the broadest, the lines of growth run parallel to it and across the longitudinal striæ; these latter give to the carinal latera a somewhat similar ornamentation to that of the scutum and tergum."

Passing over *Brachylepas cretacea*, previously described (see *ante*, p. 337), it will be seen from the foregoing account that *Brachylepas* (*Pollicipes*) *fallax* is the most important of the Cirripedes from Trimmingham, and the one about which the largest amount of evidence has been obtained as to its various valves. This species also occurs in Maestricht and Rügen, probably also in Denmark, in Hanover, and in Saxony.

Those which follow are mostly represented by single detached valves, and, although deserving notice, are of less interest to the biologist.

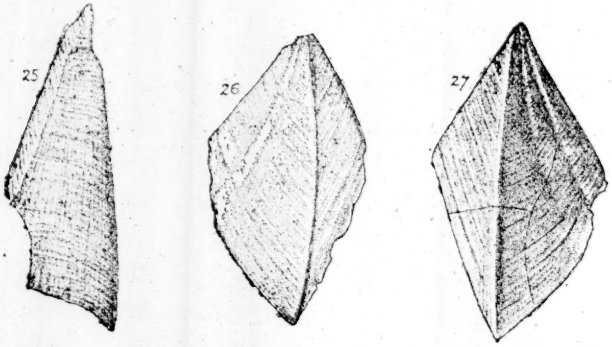


Fig. 25. *Pollicipes Angelini*, Darwin. Scutum. × 2 nat. size. Chalk, Norwich. (Dr. A. Rowe's Coll.)
Fig. 26. Ditto. Right tergum. Chalk, Trimmingham. × 2 nat. size. (Mr. Brydone's Coll.)
Fig. 27. Ditto. Left tergum. × 2 nat. size. Ditto. Ditto.

3. Pollicipes Angelini, Darwin, 1851.

Pollicipes Angelini, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), p. 56, tab. iii, fig. 7.

This form is represented in Darwin's monograph by a scutum and tergum from the Upper Chalk of Norwich (Mus. Fitch); it occurs also in the Chalk of Scania. I have referred to this species six separate *terga*, three only fairly preserved, the others very imperfect, and one *scutum*, the former all from Trimmingham; the latter is from Thorpe, Norwich, *ex* Dr. Arthur Rowe's collection.

Tergum.—The largest complete tergum (which has been broken and mended) (Fig. 27) measures 22 mm. in length by 13 mm. in breadth at its widest angle. In general outline it is rhomboidal, the

apex is acute, the base more or less obtuse; a slightly raised keel runs from the apex to the base, and divides the valve into two not quite equal halves, the occludent half being the larger; the lines of growth run parallel to the lower borders of the valve, and bend upwards on either side of the raised keel or ridge; a wide square-edged depression runs parallel to the occludent margin, which is itself rounded and protuberant. (All the terga of *P. Angelini* I have seen are from the Chalk of Trimmingham.)

Scutum.—The scutum (Fig. 25) is 21 mm. in length; its breadth is only estimated, being imperfect along its free margin; it was probably 9 mm. in breadth. Thorpe Pit, Norwich. (Coll. Dr. Rowe.)

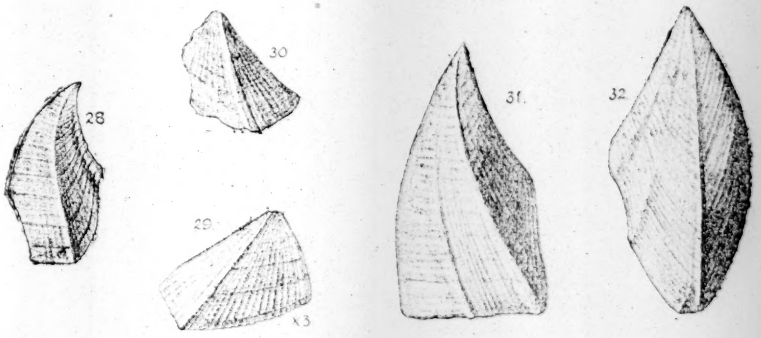


Fig. 28. ? *Pollicipes Hausmanni*, Darwin. Scutum. × 2 nat. size. Chalk, Thorpe, near Norwich. (Dr. A. Rowe's Coll.)
Fig. 29. *Pollicipes concinna*, sp. nov., H. Woodw. Carinal latus. × 3 nat. size. Chalk, Trimmingham. (R. M. Brydone's Coll.)
Fig. 30. Ditto. × 2 nat. size.
Fig. 31. ? *Pollicipes striatus*, Darw., var. *paucistriatus*, H. Woodw. Scutum. × 2 nat. size. Chalk, Trimmingham. (R. M. Brydone's Coll.)
Fig. 32. Ditto. Tergum. × 2 nat. size. Ditto.

4. ? Pollicipes Hausmanni, Darwin, 1851. (Fig. 28.)

Pollicipes Hausmanni, Koch & Dunker: Norddeutsch. Oolithgebild., p. 52, tab. vi, fig. 6.
Pollicipes Hausmanni, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), p. 53, t. iii, fig. 3.

Darwin has figured a carina, scutum, and tergum of this species from Hilsthon des Elligser Brinkes (Lower Greensand, Germany). I doubtfully refer a scutum, from Dr. Rowe's collection, to this species, obtained by him from the Chalk of Thorpe, near Norwich. Length of valve 12 mm., breadth (probably) 7 mm., basal angle broken. This is an elegant valve, with an acute and incurved apex; the base of the valve was probably straight, the inner margin curving rapidly upwards towards the tergal border; the surface ornamented by well-marked periodic lines of growth, stronger than the rest, which are parallel to the base and bend upwards on the inner occludent margin, and are slightly undulated near the tergal border.

5. (?) Pollicipes concinna, H. Woodward, sp. nov.
(Figs. 29, 30.)

There are two valves from the Trimmingham Chalk in Mr. Brydone's collection which I have been unable to collate satisfactorily with any of the species already described from the Chalk.

(*a*) In outline the smaller one (Fig. 29) agrees with the lower latus of *P. unguis* of Darwin, from the Gault, but its ornamentation is not based so much on the lines of growth as upon delicate, fine, radiating costæ diverging from its apex. The valve has two areas, separated by a well-defined ridge; the larger is 7 mm. broad at its base, the smaller, which forms with it an obtuse angle, being only $3\frac{1}{2}$ mm. broad; the height of the valve is 8 mm.; five well-marked zones of growth cross the rib-like ornamentation at irregular intervals. This is a lower latus (or a carinal latus),[1] and in default of a species to which it can be referred it may be known as (?) *Pollicipes concinna*.

(*b*) This (Fig. 30) is a larger valve than (*a*) noticed above, and possibly may belong to a distinct species. At first sight its outline seems to be not unlike a scutum, but in relative proportion it has a broader base and is shorter in height than this valve usually attains. It probably is, like (*a*), one of the lower latera, but being imperfect upon its broader facet is not so easily determined. The ornamentation is composed of radiant lines, but they are fewer in number and coarser than in the above-described form (*a*). Height, 8 mm.; width of smaller perfect side at base, 5 mm.; broader facet at base (estimated to be 6 to 7 mm.?); margin broken. The angle of this valve (*b*) is more curved than is that of (*a*); longitudinal striæ, on narrow face, about six in number, thicker at the basal margin, on broader face at least ten in number. This may have belonged to a form similar to (*a*), but its coarser striation would suggest its being possibly referred to some other species. In the absence of further information I must, however, leave it here until better material turns up.

6. (?) Pollicipes striatus, Darwin, 1851, var. paucistriatus, H. W.
(Figs. 31, 32.)

Pollicipes striatus, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), p. 70, tab. iv, fig. 5.

This form, of which a well-preserved scutum and tergum have been obtained by Mr. Brydone from Trimmingham (Figs. 31 and 32), was previously known from the Upper Chalk of Norwich (Museum Fitch), and figured by Darwin (op. cit., pp. 70–72, tab. iv, fig. 5).

I should state that these Trimmingham specimens were sent some time ago by Mr. Brydone to Professor Deecke, of Greifswald University, Prussia, who marked them as "*Scalpellum fossula*,

[1] It compares very well with the carinal latus in the living *Scalpellum striolatum* of Sars' taken between Norway and Faeroe Island (see A. Gruvel, Mon. Cirripedes, 1905, p. 64, fig. 7).

Darwin." On examination it will be seen, however, that Darwin's *S. fossula* is at once distinguished from these valves (which I identify as near to *P. striatus*) by the fact that in *S. fossula* there is a minute but well-defined longitudinal hollow groove on the summit of the ridge or keel of both the scutum and tergum; the ridge on the valves in *P. striatus* is not grooved along its summit, but is a solid well-defined ridge (as seen in Darwin's figures, op. cit., tab. iv, figs. 5*b*, *c*). Both scutum and tergum are stout, thick valves. The general form and proportions in both specimens agree best with Darwin's figures of *P. striatus* from the Norwich Chalk. In one point these valves differ from *P. striatus*, and that is in being less strongly ornamented by longitudinal striæ; but in the colour-bands and in the contour-curvature and lines of growth both valves agree very well with *P. striatus*. They are at most only a less striated variety which might be named *P. pauci-striatus*.

Tergum.—In the tergum (Fig. 32) there is seen a well-defined raised margin along the carinal border and a broad longitudinal undulation running down the valve to its baso-lateral border, which is flexuous; the more or less symmetrically rhomboidal form of the tergum is also modified by the strongly arcuate curvature of the valve, the apex leaning towards the carinal border; the free margin of the valve is also narrower than the latero-carinal side. (In *S. fossula*, as figured by Marsson, the crest of this valve is nearly straight, and the apex inclines slightly in the opposite direction to the Trimmingham fossil.) Length of tergum, 21 mm.; extreme breadth, 10 mm.; length of base of occludent carinal border, 13 mm.; on the upper carinal border, 12 mm. The longitudinal ridge is very arched, and the free border is not only narrower but more steeply inclined than the occludent side; the banded ornament produced by fine lines of growth is accentuated by colour-bands.

There is a second imperfect tergum which also comes from the same spot at Trimmingham, and shows rather stronger longitudinal striæ on the carinal side of the central ridge than the more perfect valve. It is less flat than the tergum of *P. Angelini*, among which I had in the first instance placed it, and it may possibly belong to *P. striatus*.

Scutum (Fig. 31).—Rather thick, subtriangular, tumid, and curved, apex acute, basal margin straight, 10 mm. broad, forming a right angle with the lateral margin which is 9 mm. long; tergal margin also 9 mm. long, both margins rather concave; a strongly marked rounded ridge separates the valve longitudinally from the apex to the latero-basal angle into two unequal parts, while a second less prominent line 5 mm. apart divides the occludent side of the scutum into two equal parts, the inner half being marked by seven longitudinal lines, the outer half having only horizontal lines of growth; the lateral side is also marked by a series of less prominent longitudinal lines. All these longitudinal striæ describe a strong curve, the convexity being towards the occludent margin. Colour-bands mark both the scutum and tergum, running parallel to the

basal margin and to the lines of growth. This valve agrees very well in general form with Darwin's figure of the scutum of *P. striatus* (op. cit., tab. iv, fig. 5*c*), except that the longitudinal striæ are less strongly pronounced.

It is probable that *P. striatus* may belong to the genus *Scalpellum*, but I hesitate to remove it without fuller knowledge of the other valves belonging to this species.

7. Pollicipes glaber, Roemer.

Pollicipes glaber, Roemer: Norddeutsch. Kreidegebirg, tab. xvi, fig. 11.
Xiphidium maximum, J. Sowerby: Dixon's Geol. Sussex, tab. xxviii, figs. 6–8.
Pollicipes glaber, Darwin, 1851: Mon. Foss. Lepadidæ, Pal. Soc. Mon., p. 61, tab. iii, figs. 10*a–l*.

I must not omit to mention some six small, smooth, but rather imperfect valves of a Cirripede from Trimmingham, marked by Mr. Brydone as having been found by him 'connected.' I am able readily to identify them with Darwin's figures of *Pollicipes glaber* (tab. iii, figs. 10*a–l*, op. cit.) from the Chalk of Stoke Ferry, Norfolk. This species also occurs in the Upper Chalk of Northfleet and Gravesend, Kent, and the Chalk Detritus of Charing, Kent, and from numerous localities on the Continent.

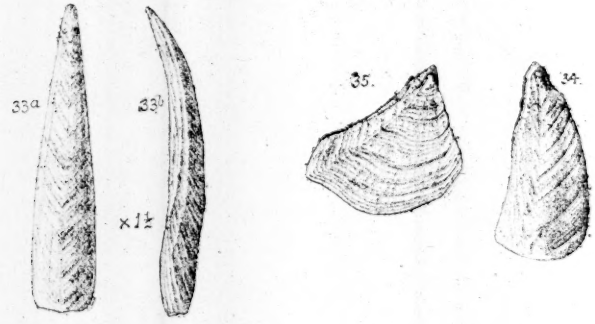


Fig. 33*a*. *Scalpellum maximum*, Darwin. Carina (back view). Chalk, Norwich. (Dr. A. Rowe's Coll.)
Fig. 33*b*. Profile of ditto. × 1½ nat. size. (Dr. A. Rowe's Coll.)
Fig. 34. Ditto. Tergum. (Fragment only.) × 2 nat. size. Ditto.
Fig. 35. Ditto. Carinal latus. × 2 nat. size. Ditto.

Mr. Brydone's Trimmingham specimens comprise a scutum, a tergum, a rostrum, an upper and a lower latus. I do not think it is needful to refigure them here, but they are important as having been found in association in the same piece of chalk.

8. Scalpellum maximum, Darwin, 1851. (Figs. 33*a*, *b*, 34, 35.)

Pollicipes maximus, J. Sowerby: Min. Conch., table 606, figs. 4, 6 (*not* figs. 3, 5).
Pollicipes maximus, Steenstrup: Kroyer Tidsskrift, bd. ii, pl. v, figs. 17, 18.
Pollicipes medius, Steenstrup: Kroyer Tidsskrift, bd. ii, pl. v, figs. 13, 13*, 33.
Pollicipes sulcatus, J. Sowerby: Min. Conch., pl. 606, fig. 2 (*not* figs. 1, 7).
Scalpellum maximum, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), pp. 26–34 (and varieties), tab. ii, figs. 1–10.

My father, in his "MS. Illustrations" (tab. xi, figs. 5*a*, *b*), prepared to accompany a published "Synoptical Table of British Organic Remains," by Samuel Woodward (4to and 8vo, 1830, p. 9; London, Longmans & Co.), gives drawings of the tergum and carina of this species (under the genus *Pollicipes*) from the Norwich Chalk.

I have received from Dr. Rowe a very well preserved carina (although wanting a portion of its base) obtained by him from Edward's Chalk Pit, Mousehold, Norwich, measuring in its present state 30 mm. in length by 7 mm. in breadth at its widest part, its profile being 4 mm. deep. It has numerous ⩔-shaped lines of growth passing over the keel, the point directed downwards, ten of which are more prominent than the rest. There are also several longitudinal striæ extending from the apex to the base (Figs. 33*a*, 33*b*). Two longitudinal folds mark the narrow lateral portions of the carina, which is sharply recurved at its apex.

Dr. A. Rowe has also kindly sent me a carinal latus of *Scalpellum maximum*, which agrees with the figure of that valve given by Darwin (op. cit., tab. ii, figs. 4*a–c*). It is from Attoe's Pit, New Catton, Norwich (*B. mucronatus* zone). Darwin states that his figure was taken from a specimen from Kopinge in Scania. Dr. Th. Marsson (in his "Cirripedien d. Rügenschen Kreide," taf. i, fig. 2) figures and describes a precisely similar valve, which he says is a carinal latus of *Sc. maximum*. Another small specimen is recorded by Darwin from Charing in Kent (op. cit., p. 32). "Valve thin, of an irregular shape (Fig. 35), sub-triangular, flat, except at the umbo, which projects outwards, owing to a ledge formed beneath and round it; carinal margin very slightly convex, with a linear furrow parallel to it, between which and the edge the lines of growth are abruptly upturned; lower margin considerably convex, upper margin slightly concave, with a slight depression parallel to it, between which and the edge the lines of growth are rectangularly reflected towards the umbo." Height of valve 12 mm., greatest breadth 12 mm.

Mr. Brydone considers it very doubtful as to whether this form occurs in the Trimmingham Chalk, but in looking over some fragments of valves in Mr. Brydone's Trimmingham collection, associated with terga of *P. Angelini* and a scutum and tergum of *P. striatus*, var. *paucistria*, I found a broken scutum of *Scalpellum maximum*. It was a very large and very thick valve, and displays on its inner surface the depression for the adductor muscle. The outer surface has the usual lines of growth and fine longitudinal striæ seen in the other valves belonging to this species. Length of fragment 18 mm., greatest breadth 10 mm. From the proportionate size and thickness of this fragment I am led to conclude that it must have really belonged to *S. maximum*.

Tergum (Fig. 34).—This is only a fragment (from Dr. A. Rowe's collection), but from its form and lines of growth I have no difficulty in recognising it as the apex of a tergum of *S. maximum*. Cf. Darwin's figures of this valve (tab. ii, figs. 7*a*, *b*). It is a narrow crescent-

shaped valve (not unlike a boomerang), broad and pointed at its base, much curved and thickened at its free apex by the infolding and union near its summit of the two lateral walls. A fine furrow runs down the exterior surface of the narrow valve, where the usual prominent ridge of the tergum is seen, nearly parallel to the carinal margin.

9. Scalpellum fossula, Darwin, 1851. (Fig. 36.)

Scalpellum fossula, Darwin, Foss. Lepadidæ, 1851: Mon. Pal. Soc., 4to, pp. 24, 25, tab. i, fig. 4.
Pollicipes maximus, J. Sowerby: Min. Conch., table 606 (a tergum), fig. 3.

Tergum (Fig. 36).—A single left tergum in Dr. Rowe's collection is from the Chalk of Thorpe, Norwich. It is thin, narrow, almost smooth, but instead of a ridge running from the apex to the lowest

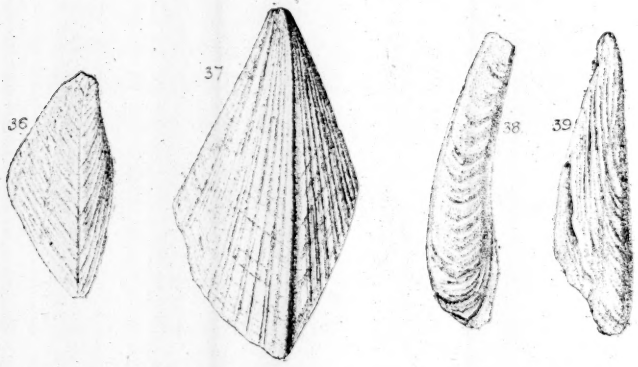


Fig. 36. *Scalpellum fossula*, Darwin. Left tergum. × 2 nat. size. Chalk, Thorpe, Norwich. (Dr. A. Rowe's Coll.)
Fig. 37. *Scalpellum attenuatum*, sp. nov., H. Woodw. × 2 nat. size. Chalk, Harford Bridges Pit, Norwich. (Dr. Rowe's Coll.)
Fig. 38. ? *Brachylepas*. Latera. × 2 nat. size. Chalk, Trimmingham. (Mr. R. M. Brydone's Coll.)
Fig. 39. Ditto. Same valve as Fig. 38, side view, showing great thickness of valve.

point of the obliquely diamond-shaped valve, the line is marked by a delicate furrow, as shown in Darwin's figure (tab. i, fig. 4*b*, op. cit.). This furrow divides the valve unequally into a very narrow area along the carinal border, and a much wider one, bounded by the scutal margin below and the occludent margin above, the centre of which is again subdivided by a single longitudinal line. Length of valve, 16 mm.; greatest breadth, 8 mm.; scutal margin, 11 mm.; occludent margin, 10 mm.

Recorded by Darwin from the Upper Chalk of Norwich and from Northfleet, Kent.

10. Scalpellum attenuatum, H. Woodw., sp. nov. (Fig. 37.)

Among the collection of specimens sent to me by Dr. Arthur Rowe from the Norwich Chalk is a single tergum from Harford Bridges Pit,

which is unlike any of those already noticed. In general form this valve resembles the tergum of *S. arcuatum* from the Gault of Folkestone; it may also be compared with that of *S. solidulum* from Scania; in all three *terga* the ornamentation consists of a series of longitudinal raised lines diverging from the apex of the valve at unequal distances apart, some being relatively finer than the others. In *S. arcuatum* the main ridge, passing down the centre of the valve from the apex to the basal extremity, is grooved, whereas in the specimen before us the valve has a well-defined rounded ridge. The radial longitudinal lines on the carinal side of the ridge are extremely fine, and broader and stronger on the outer half of the valve than on the inner side of the main ridge. The occludent margin has a strongly raised border, followed by a wide groove extending from the apex to the scutal margin. The lines of growth are most strongly marked on the occludent margin, but they can be faintly seen over the whole valve. On the inner side of the valve the apex (more particularly on the carinal margin) becomes greatly thickened.

Extreme length of valve, 24 mm.; extreme breadth, 13 mm.; length of occludent margin, 16 mm.; of the carinal margin, 13 mm.; and of the carino-lateral margin, 15 mm. The scutal margin is convex; the carino-lateral margin forms an obtuse angle, the sides of which are straight; the occludent margin is very slightly concave.

The two valves already noticed from Mr. Brydone's collection of Trimmingham Cirripedes, under the tentative name of *P. concinna*, are the only two other valves in the collection having a similar ornamentation of finely radiating longitudinal lines, but we have no other grounds for associating these detached valves together, Dr. Rowe's (as already stated) being from an entirely different locality and horizon (?) in the Chalk.

11. Brachylepas (?), sp. (Figs. 38, 39.)

Latera (Figs. 38 and 39).—We give two views of a remarkable form of detached latus, but it is uncertain to what species of Cirripede it belonged. This is a narrow, elongated, irregular valve, and but for the fact that it is extremely solid it might readily be overlooked and thrown aside as merely part of a very narrow-valved *Ostrea*. There are in all five specimens from the Trimmingham Chalk, having the same ornamentation as shown in the figured example. Two of these are from Mr. Clement Reid's collection, and three from that of Mr. Brydone. There are three other fragments not quite so robust and having a distinctly V-shaped ornament similar to that on the carina of *Scalpellum maximum*, and possibly they were latera of that species. Length of figured specimen, 22 mm.; greatest breadth, 5 mm.; greatest thickness, 6 mm.

Similarly-formed latera occur in *Brachylepas fallax* (Figs. 21, 22, p. 344); also in the recent *Pollicipes mitella* (see Fig. B, *ante*, p. 340, *l*) and many others.

II.—Notes on some Microzoa and Mollusca from East Crete.

By Rev. R. Ashington Bullen, B.A., F.G.S.

(PLATES XVIII and XIX.)

THE fossil or sub-fossil remains to which I propose to devote this short paper were procured from a cave-deposit in East Crete by Miss Dorothea M. A. Bate, whose valuable work among the Pleistocene Mammalia in Crete is so well known.

Early in 1905 she kindly sent me some helicoid shells from a cave-deposit in East Crete, together with an interesting collection of land and fresh-water mollusca from various parts of the island, all which I have recorded elsewhere.[1] There were also some marine mollusca found at Kutri, West Crete, in a cave about 25 feet O.D. Mr. E. A. Smith, F.Z.S., identified one as *Calliostoma Laugieri* (Payraudeau), and there were others in the same cave-deposit, which, recognizing as marine, Miss Bate did not collect. These occurred in the same cave, in a crevice of which was also a quantity of sea-sand.

The new material, very small in amount but very great in interest, Miss Bate procured from a large mammalian bone of Pleistocene date, found by her in a cave at Kharoumes, East Crete, 12 to 15 feet O.D.; and, as the minute organisms found therein are all of a marine facies, their evidence, added to the other facts from Kutri, points to oscillations of the land-surfaces, leading to the submergence and re-emergence of those land-surfaces, other evidences of which were commented on by Raulin and Spratt more than 40 years ago, in 1861 and 1865 respectively. The late eminent geologist, Professor Prestwich, carefully summed up their evidence as follows[2]:—"From M. Victor Raulin's work on Crete I gather that there is evidence of the elevation of the island within the historical period to the extent of 15 to 25 feet, and, further, that at a height of about 65 feet a raised beach of Quaternary age is met with at many points of the coast. Admiral Spratt has shown that within recent times there has been a subsidence of the east coast of Crete, whilst the west side has been elevated to the extent of 26 feet.[3] Anchor blocks have been found 11 feet above the sea-level, and the port of Kissamo has been raised 18 feet out of the sea within Christian times. The two piers of the port of Phalasarna,[4] a city of late Hellenic date, and described by Strabo, are now 22 feet above their original level.[5] Spratt also found *Pectunculi* of recent species 40 feet above the shore, and indications of another raised beach, or old sea-level, at 100 feet."

[1] Proceedings of the Malacological Society, vol. vi, p. 307.

[2] Prestwich, "Evidences of the Submergence of Western Europe and the Mediterranean Coasts": Phil. Trans., vol. 184 (1893), p. 969.

[3] Spratt: "Travels and Researches in Crete," vol. ii, p. 241 (the district between Selino and Lissos).

[4] Now Kutri.

[5] Bate: Geol. Mag., Dec. V, Vol. II (1905), p. 199 sqq.

The evidence brought home by Miss Bate tends, in my opinion, to reinforce and corroborate the observations summed up by Prestwich in the above passage.

In a recent volume of the Geological Magazine Miss Bate has described this district in her account of her "Search for Pleistocene Mammalia in Crete."[1] The only cave-deposits found in this part of the island were situated in the rugged limestone cliffs bordering the southern end of the Bay of Kharoumes, not many miles south of Palaikastro. At the foot of these cliffs, and only a few feet to a few yards above the sea, were discovered one small bone-cave, and, on either side, portions of the stalagmitic flooring of two others; all being situated closely together and extending for a distance of a hundred and fifty yards.

In Spratt's map of Eastern Crete[2] the Bay of Kharoumes appears as Caruba, and in the French military map[3] as Carouba for both village and bay, which latter spelling Spratt also uses for the name of the village. As Miss Bate invariably calls the place and bay by the name Kharoumes, this is undoubtedly the later current Cretan form. But to the south of Carouba is a village marked in the French map Asokiramo, which is unnoticed in Spratt's map, and is evidently nearer the original of the name Kharoumes. So acute an observer as Spratt would not be likely to make a mistake in the spelling of a name, especially as he says the karouba[4] is the chief produce, and a village to the north of Zakro Bay is named from it. So here in the text we get yet another spelling of the name! Probably Spratt was not responsible for the spelling of the map, as other persons' names are appended to it, but it is all very puzzling and does not make for clearness or exactitude. And may one venture to say that even in England nothing is more common than the variation in a place-name, and that many of the names differ now from their pronunciation and spelling at the time of the engraving of the Survey maps, though there is sufficient similarity in the variants for purposes of identification.

The Kharoumes Bay district, according to Spratt's Geological map, presents a somewhat central mass of slates and schists, surrounded by a limestone district, flanked on the north, west, and south-east by marine Tertiary deposits. It was in the limestone part of this district only that terrestrial mollusca so far have been found in the stalagmitic breccia.

With regard to the marine microzoa from the same place, critically examined for me by Mr. R. Holland, his report is as follows:—"This material, although very small in amount, has proved extremely interesting on account of the very striking series of varieties of

[1] Spratt: op. cit., vol. ii, pp. 230–2. See also ibid., vol. ii, pp. 135–6. (Evidence of successive uplifts indicated by wave-abrasion and the occurrence of boring molluscs in the cliffs; many shells still *in situ*.)

[2] Op. cit., vol. i, *ad fin.*

[3] Ile de Crète: dessiné et heliogravé au Service Géographique de l'Armée.

[4] The carob-tree, or St. John (the Baptist's) Bread, is found wild in all countries skirting the Mediterranean. At Malta it is almost the only tree. In Spain we get its Moorish name, algarroba.

Peneroplis pertusus (Förskal). This foraminifer is remarkable for its great morphological range, and, although most authors have given specific names to many of the varying forms, it is now generally held that all these are simply varieties of one protean species (see vol. ix of the 'Challenger' Reports). The occurrence in this small amount of material of so wide a range of forms strongly supports this view. With the exception of *Peneroplis pertusus*, *Planorbulina mediterranensis*, and *Miliolina reticulata*, the specimens are generally poorly developed." The reason of this we shall see immediately.

The total number of specimens is 148. Some of these are obscured in places by the reddish cement by which they were kept in adhesion to each other and to the bone on which they were found. The worn appearance of a large proportion of them testifies to their great age. On examination with a $\frac{1}{6}$ objective the foraminiferal tests, where broken, are seen generally to be filled with a shining crystalline calcitic material stained red, a colour evidently derived from the cave-earth; some of them, especially *Orbitolites complanata*, are covered with a calcitic crust, which hides the foramina, and there is in the hollows between the striæ of others a chalky-looking paste, white in colour, seemingly derived from the attrition or solution of other foraminiferal tests. The polyzoa also have become crystalline in substance from the infiltration of a calcitic solution. All these characters explain why Mr. Holland, from the microscopist's point of view, reports the specimens as poorly developed, for these characters differentiate them from recent specimens of the same species and betoken their fossil or sub-fossil character.

LIST OF SPECIES FOUND.

Mollusca.

Terrestrial.

Helix pellita,[1] [2] Fér. Cave-breccia, Kharoumes.

Marine.

Calliostoma Laugieri[2] (Payraudeau). Pleistocene mammalian bone, cave, Kutri.

Cardium sp.

Rissoa crenulata, Montagu. Pleistocene mammalian bone, cave, Kharoumes.

Crustacea.

Valves of *Entomostraca*. Ditto.

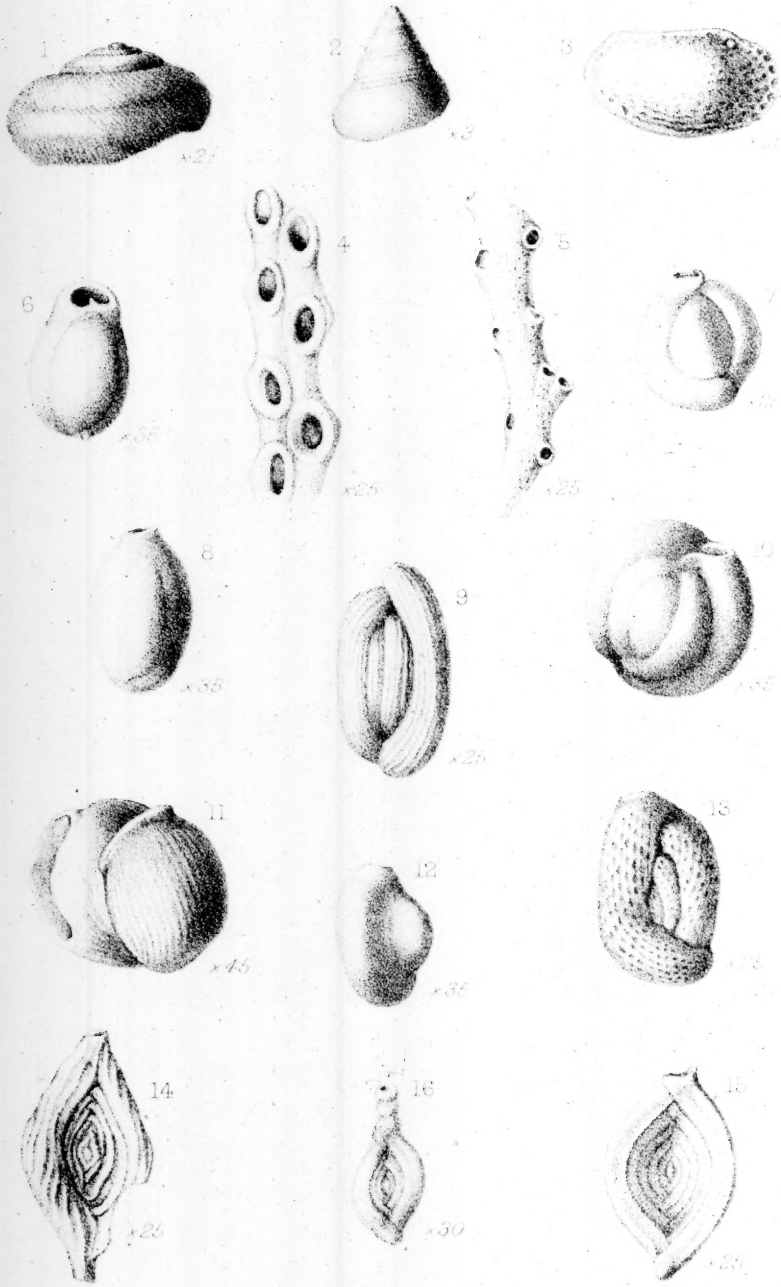
Polyzoa.

Crisia eburnea (Linné). Ditto.

Bugulopsis sp.

[1] Recorded by Pilsbry as a recent shell at Morea, Syra, and Rhodes. Its occurrence at Kharoumes is believed to be its first record from a Pleistocene deposit. From available evidence it appears not now extant in Crete.

[2] Specimens now in Geological Department, British Museum.



G.M. Woodward del. et lith. West, Newman imp.

Mollusca, Bryozoa & Foraminifera from Crete.

FORAMINIFERA.

Biloculina elongata (D'Orb.). Pleistocene mammalian bone, cave, Kharoumes.
Dentalina sp.
Discorbina globularis (D'Orb.). Ditto.
D. opercularis (D'Orb.). Ditto.
D. orbicularis (Terquem). Ditto.
D. turbo (D'Orb.). Ditto.
Globigerina bulloides[1] (D'Orb.). Ditto.
Miliolina seminulum (Linn.). Ditto.
M. oblonga (Montagu). Ditto.
M. bicornis (Walker & Jacob). Ditto.
M. subrotundata (Montagu). Ditto.
M. valvulata[2] (Reuss). Ditto.
M. tricarinata (D'Orb.). Ditto.
M. reticulata (D'Orb.). Ditto.
M. circularis (Bornemann). Ditto.
Orbitolites complanata (Lamk.). Ditto.
Peneroplis pertusus (Förskal). Ditto.
Planorbulina mediterranensis, D'Orb. Ditto.
Polymorphina lactea[2] (Walker & Jacob). Ditto.
Polystomella macella (Fichtel & Moll.). Ditto.
Rotalia becarii (Linn.). Ditto.
Rotaline form undetermined. Ditto.
Spiroloculina grata, Terquem. Ditto.
S. limbata, D'Orb. Ditto.
Truncatulina lobatula (Walker & Jacob). Ditto.
T. ungeriana (D'Orb.). Ditto.
Vertebralina striata (D'Orb.). Ditto.
V. sp.[3] Ditto.

I have the pleasure of thanking the friends mentioned in the paper for help, also Mr. R. Bullen Newton, F.G.S., for submitting the material from Kharoumes to Mr. R. Holland, and Professor T. Rupert Jones, F.R.S., for critically reading my MS.

EXPLANATION OF PLATES.

PLATE XVIII: MOLLUSCA, BRYOZOA, FORAMINIFERA, ETC., FROM CRETE.

FIG.
1. Mollusca: *Helix pellita*. × 2½.
2. ,, *Calliostoma Laugieri*. × 3.
3. Crustacea: Valve of Entomostracan, *Loxoconcha* sp.
4. Bryozoa: *Bugulopsis* sp. × 25.
5. ,, *Crisia eburnea*. × 25.
6. Foraminifera: *Biloculina elongata*. × 35.
7. ,, *Miliolina seminulum*. × 25.
8. ,, *M. oblonga*. × 35.
9. ,, *M. bicornis*. × 25.
10. ,, *M. subrotunda*. × 35.

[1] With abnormal aperture (Holland).
[2] Striate variety (Holland).
[3] With spiroloculine early chambers (Holland).

FIG.
11. Foraminifera: *M. valvulata.* × 45.
12. ,, *M. tricarinata.* × 35.
13. ,, *M. reticulata.* × 25.
14. ,, *Spiroloculina grata.* × 25.
15. ,, *S. limbata.* × 25.
16. ,, *Vertebralina* sp. × 30.

PLATE XIX: FORAMINIFERA FROM CRETE.

1. Foraminifera: *Peneroplis pertusus.* × 25.
2. ,, ,, × 35.
3. ,, ,, × 25.
4. ,, ,, × 35.
5. ,, *Dentalina* sp. × 25.
6. ,, *Orbitolites complanata.* × 25.
7. ,, ,, × 50.
8. ,, *Polymorphina lactea.* × 25.
9. ,, *Globigerina bulloides.* × 30.
10. ,, *Planorbulina mediterranensis.* × 30.
11. ,, *Discorbina globularis.* × 45.
12. ,, *D. opercularis.* × 45.
13. ,, *D. orbicularis.* × 45.
14. ,, *D. turbo.* × 45.
15. ,, *Truncatulina lobatula.* × 45.
16. ,, *T. ungeriana.* × 45.
17. ,, *Rotalia becarii.* × 45.
18. ,, *Polystomella macella.* × 45.

III.—SEDGWICK MUSEUM NOTES.

NEW FOSSILS FROM THE HAVERFORDWEST DISTRICT.

By F. R. COWPER REED, M.A., F.G.S.

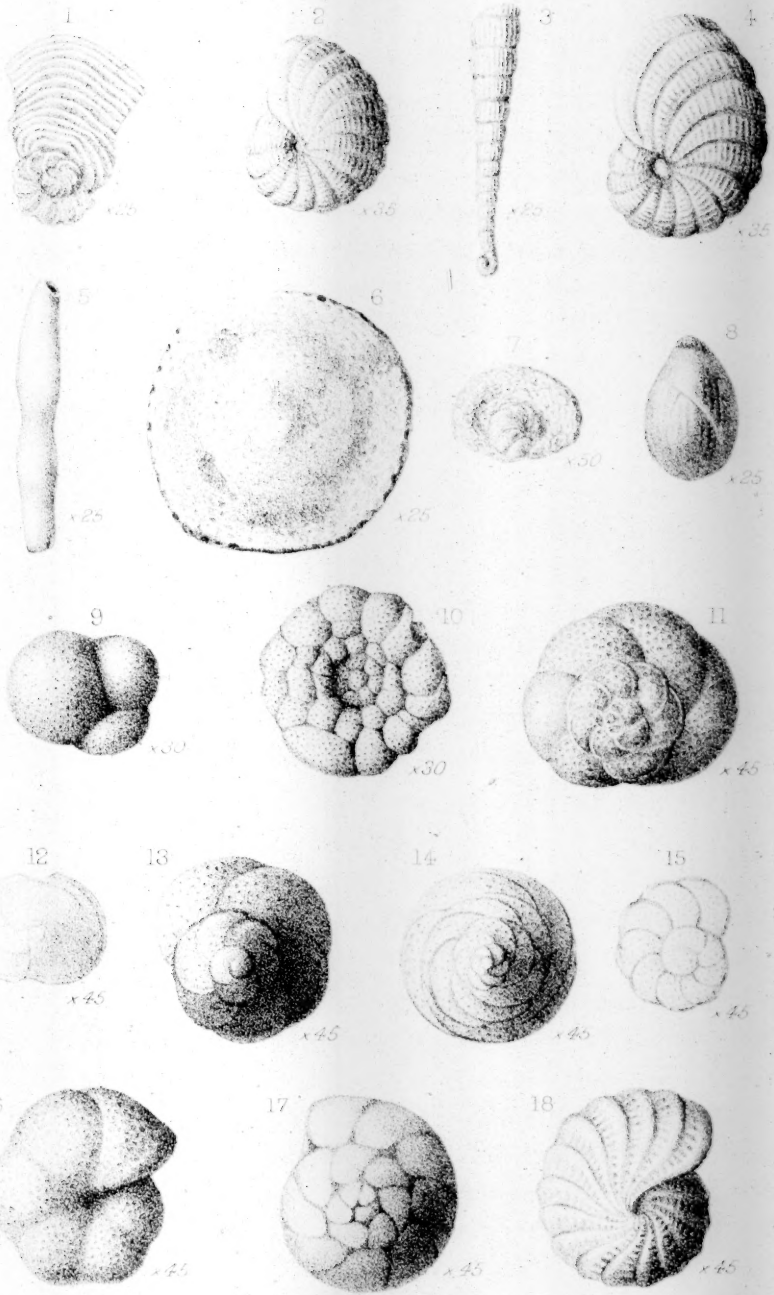
(PLATE XX.)

GASTEROPODA.

A FEW Gasteropoda were recorded by Messrs. Marr and Roberts[1] from the *Trinucleus seticornis* Beds, principally from the Redhill stage, but Mr. Turnbull has been fortunate in obtaining a comparatively large number of species. The specimens are not usually well preserved, and the specific or even generic determination of all is not possible with the present material. Some interesting new forms, however, can be detected, and the following list can now be given:—

R. *Eotomaria Robertsi*, sp. nov.
R. *E.* cf. *elliptica*, His.
R. *E.* sp.
R, S. *Liospira* sp.
S. *Lophospira* cf. *turrita*, Portl.
R. *L.* sp.
R. *Hormotoma* (?) sp.
S. *Clathrospira* (?) sp.
S. *Trochonema* sp.

[1] Marr & Roberts, Quart. Journ. Geol. Soc., vol. xli (1885), pp. 476-490.



F.M.Woodward del. et lith. West, Newman imp.

Foraminifera from Crete.

R, Sh. *Holopea concinna*, McCoy.
S. *Holopella* sp.
R. *Loxonema* sp.
R. *Ophiletina* (?) sp.
R. *Eccyliomphalus minor*, Portl.
R. *Bellerophon* (*Sinuites*) *crypticus*, sp. nov.
R. *B.* (*Bucanopsis*) *secundus*, sp. nov.
R. *B.* (*Oxydiscus* ?) sp.
R. *B.* (s.g. ?) *multirugatus*, sp. nov.
Sh. *B.* (s.g. ?) sp.
S. *Conradella* (?) sp.
R. *Archinacella Prendergasti*, sp. nov.
R, S. *A.* aff. *rotunda*, Ulrich.

Of the foregoing those marked R. occur in the Redhill Beds those marked S. in the Slade Beds, and those Sh. in the Sholeshook Limestone.

EOTOMARIA ROBERTSI, sp. nov. (Pl. XX, Figs. 1–4.)

Shell low, conical, of 5–6 flat whorls; apical angle 90°–110°; base convex; periphery angular; mouth obliquely subrhomboidal, wider than high; umbilicus very small, deep, partly covered by reflexed inner lip of mouth. Band concave, narrow, with sharp raised borders, the lower edge forming the periphery of the whorls; lunulæ of band very faint. Surface of whorls nearly flat; ornamented with fine, simple, oblique, curved lines of growth, meeting suture-line above at about 75°, but curved strongly back near band so as to meet it at 20°–25°. Base of shell more or less swollen, especially towards mouth, and marked by strong growth-lines.

Dimensions average about 18 mm. in basal diameter.

Horizon.—Redhill Beds.

Localities.—Prendergast Place and Lane, Haverfordwest.

Remarks.—The genus *Eotomaria* was established by Ulrich [1] for a certain type of shell differing from *Pleurotomaria* in merely having a notch in the outer lip and no slit; in the lower edge of the band forming the periphery of the whorls; in the lines of growth curving more or less forward beneath the band; and in the surface being marked by simple lines of growth only. The complete definition of the genus was given as follows: "Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-height; aperture oblique, subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band of moderate width, concave, sharply defined, oblique or horizontal, lying upon the apical side of the periphery. The surface markings consist of fine lines of growth only. These curve

[1] Ulrich & Scofield: Final Rep. Geol. and Nat. Hist. Surv. Minnesota, vol. iii (1897), pt. 2, pp. 954, 1000.

backward more or less strongly toward the band on both the upper and lower sides of the whorls. Type, *E. sublævis*, Ulrich."

The specimens from the Redhill Beds occur only as internal casts or external impressions of the shell, and are generally more or less crushed and distorted. They are the commonest gasteropods on this horizon, and from the examination of a large series of specimens the above description has been drawn up. The characters of the base, umbilicus, and inner lip are always distinct, and the position and peculiarities of the band and surface-markings are clearly preserved on two or three shells.

A comparison with Ulrich's figures and descriptions of American species suggests that our Redhill form is closely allied to *E. canalifera*, Ulrich,[1] and *E. labiosa*, Ulrich,[2] from the Stones River Group of Tennessee. The well-known species generally known as *Trochus ellipticus*, Hisinger, from the Ordovician of Northern Europe is a much more elevated and conical shell with a smaller apical angle. The subgenus of *Pleurotomaria* which has been named by Miss Donald *Palæoschisma*[3] is said to differ from *Eotomaria* in having "a distinct though short slit, instead of a sinus in the outer lip." In the case of our Haverfordwest specimens of *E. Robertsi*, the state of preservation has not permitted me to determine whether a sinus or slit is present, but they differ much more from the type and only species of *Palæoschisma* (*P. girvanense*) in all other observable characters than they do from the above-mentioned species of *Eotomaria*, so that their reference to the latter genus appears fairly certain.

Eotomaria cf. elliptica (Hisinger).

In addition to *E. Robertsi*, a taller, more conical species of *Eotomaria* occurs which, so far as it is preserved, appears to be comparable to the Ordovician form described by Hisinger as *Trochus ellipticus*.[4] One specimen from the Redhill Beds of Prendergast Place has an apical angle of 60°, a height of 18 mm., and a basal width of about 15 mm. The species was believed by Portlock[5] to occur in the Ordovician of Tyrone, but Miss Donald (op. cit., p. 337) declares that it is a distinct species, and she would apparently place Hisinger's shell in her subgenus *Palæoschisma*.

Horizon.—Redhill Beds.

Localities.—Prendergast Place and Lane, Haverfordwest.

Lophospira cf. turrita, Portlock. (Pl. XX, Figs. 6, 6*a*.)

Shell elevated, turreted, composed of about 5 (?) whorls with subangular periphery above middle and rather rapidly increasing in size to base; basal whorl ventricose, high. Apical angle 50°. Upper surface of whorls with one prominent carina about two-thirds the

[1] Ulrich: op. cit., p. 1002, pl. lxix, figs. 9–14.
[2] Ulrich: op. cit., p. 1003, pl. lxix, figs. 15–17.
[3] Donald: Quart. Journ. Geol. Soc., vol. lviii (1902), p. 335, pl. ix, figs. 11, 11*a*.
[4] Hisinger: Leth. Suec., 1837, p. 35, pl. xi, fig. 1. Lindström: Silur. Gastrop. Pterop. Gotland, p. 104, pl. viii, figs. 10–14. Koken: Bull. Acad. Imper. Sci. St. Petersb., ser. v, vol. vii (1897), No. 2, p. 152.
[5] Portlock: Geol. Rep. Londond., p. 414, pl. xxxi, fig. 1.

distance from band to suture, and one weaker one nearer the suture. Band peripheral (submedian on upper whorls), rather wide, trilineate with raised linear margins and stronger submedian raised line; lunulæ frequent, rather strong. Outer face of whorls with faint revolving carina below band at about twice its width, and another fainter one at same distance below. On outer and lower surface of basal whorl below the band there are in addition distinct spiral revolving lines regularly and closely placed. Upper surface of whorls crossed by regular, strong growth-lines meeting band at 60°, and continued below it on outer and lower surface of whorls.

Dimensions:

Height	about 18 mm.
Basal width	,, 12·5 mm.

Horizon.—Slade Beds.

Locality.—Lane between Slade Hall and Pelcombe Bridge.

Remarks.—This species, though at present too imperfectly known to merit a distinctive name, undoubtedly belongs to the genus *Lophospira* as defined by Ulrich,[1] and it possesses many points of resemblance to *L. bicincta* (Hall),[2] but the band and carinæ are rather different. It is probably distinct from any British Bala species so far described, though *M. pulchra*, McCoy,[3] seems allied to it. But an examination of the supposed type of *Pleurotomaria turrita*, Portlock,[4] in the Jermyn Street Museum has convinced me that its nearest relation is found in this species, and it may best be compared with it, pending its specific separation.

LIOSPIRA sp. (Pl. XX, Figs. 7, 7*a*.)

Shell heliciform, low, depressed-conical, of 4–5 rounded whorls coiled into a low spire; base convex, rounded; whorls increasing in size rather rapidly to mouth; sutures more or less sunken; apical angle 130° or more; body-whorl higher than spire, with rounded periphery. Band of moderate width, not prominent, subperipheral, situated on body-whorl a little above middle, hidden on other whorls by their overlap. Ornamentation of shell consisting of fine, transverse lines of growth, curved back sharply to meet band, and continued on lower surface of body-whorl (base not well preserved).

Dimensions:

	I.	II.
Height	7·5	5 mm.
Diameter	11·5	8 mm.

Horizons.—Slade Beds (II); Redhill Beds (I).

Localities. — Roadside near St. Martin's Cemetery, Haverfordwest (II); Prendergast Place (I).

Remarks.—The specimens are not sufficiently well preserved to determine the species, but their reference to the genus *Liospira* as defined by Ulrich[5] is indisputable. So far as this form can be

[1] Ulrich: op. cit., pp. 951, 960.
[2] Hall: Palæont. N.Y., vol. i, p. 177, pl. xxxviii, figs. 5*a*–5*f*.
[3] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus., p. 294, pl. 1*k*, figs. 42, 42*a*.
[4] Portlock: op. cit., p. 413, pl. xxx, figs. 7*a*, 7*b*.
[5] Ulrich: op. cit., pp. 953, 992.

compared with others, we may mention *Pleurotomaria helicina*, Lindström,[1] and especially *Pl. æquilatera*, Wahlenb.,[2] as bearing much resemblance to it.

TROCHONEMA sp.

There is one fairly good but compressed specimen from Upper Slade in Mr. Turnbull's collection which must be referred to this genus. The shell is conical, of 4–5 whorls (only 3 are preserved); the whorls are rather low, with their upper surface more or less flattened and horizontal, their periphery angular and carinate, and their outer face nearly vertical to the suture; the base of the shell is more or less convex and rounded. On the upper surface of the whorls there is a shoulder-like, flat space round the suture; a weak carina separates it from the rest of the upper surface, which is slightly concave. The peripheral carina is strong and prominent, and the outer side of the whorl below it is nearly at right angles to the upper surface, and bears, low down, traces of one or two faint revolving carinæ. The whole surface of the whorls is crossed by coarse, oblique, continuous growth-lines, meeting the peripheral carina at about 45°, and passing over it and over the upper surface of the whorls without deflection. Apical angle of shell 100°–120°. Height about 21 mm.; basal width about 17 mm.

Horizon.—Slade Beds.

Locality.—Quarry at Upper Slade.

Remarks.—This imperfectly-known shell resembles in many respects *T. umbilicatum*, Hall,[3] but the obliquity of the growth-striæ is a distinguishing feature.

ARCHINACELLA PRENDERGASTI, sp. nov. (Pl. XX, Figs. 8, 8*a*, 9.)

Shell subcircular or subelliptical, equally rounded at both ends, convex, rounded, subconical, rather high, with highest point situated subcentrally behind apex; apex submarginal, incurved, sharp, not overhanging margin, but surface of shell below it steep and more or less excavated. Rostral scars large, oval, with traces of a small circular pair behind them and more closely placed together. Muscular band forming small, continuous loop, extending back a little over two-thirds the distance from apex to posterior end. Surface of shell marked by concentric, slightly wavy growth-lines, strongest near margin.

Dimensions (both specimens are somewhat crushed):

	I.	II.
Length	13·50	22·0 mm.
Width	17·30	13·5 mm.
Height	7·75	8·5 mm.

Horizon.—Redhill Beds.

Locality.—Prendergast Place, Haverfordwest.

[1] Lindström: op. cit., p. 124, pl. xi, figs. 34–37.
[2] Lindström: op. cit., p. 111, pl. ix, figs. 20–29.
[3] Hall: Palæont. N.Y., vol. i (1847), pp. 43, 175. Ulrich: op. cit., p. 1047, pl. lxxvii, figs. 1–8.

Remarks.—There are only two specimens of this shell in Mr. Turnbull's collection, and one (No. II) is somewhat laterally compressed and the other rather crushed. But sufficient characters are preserved to show we have to deal with a new species. The character by which the genus *Archinacella*[1] is principally distinguished from *Tryblidium*[2] is the possession of a continuous muscular loop instead of separate pairs of muscles arranged round the shell. The definition of the genus *Archinacella* is given by Ulrich, its founder, as follows (op. cit., p. 821) :—"Shell patelliform, ovate to subcircular, usually widest anteriorly, forming a low cone with the apex in front of the centre and often submarginal. Muscular scars forming a continuous band. Surface markings concentric only. Type, *A. powersi*, Ulrich."

A species which seems deserving of comparison with our Redhill form is *A. valida* (Sardeson)[3] from the Trenton Group of Minnesota; and Billings' *Metoptoma simplex*[4] from the Calciferous formation appears to have precisely the same contour and shape.

Archinacella aff. rotunda, Ulrich. (Pl. XX, Figs. 10, 10*a*.)

There is a smaller and apparently distinct species of *Archinacella* occurring in the Redhill and Slade Beds, which is, however, scarcely sufficiently known at present to warrant a new specific name. It is nearly circular in shape, strongly convex, with the sharp pointed apex vertically above and slightly overhanging the anterior margin; the shell is highest in the middle, and the apex is rather depressed and incurved, being only about half the maximum height of the shell above the margin. No surface-markings are distinguishable. This species appears to resemble Ulrich's *A. rotunda*[5] from the Utica Group of Iowa.

Dimensions :

Length	... ...	5·5 mm.
Width	... ...	5·5 mm.
Height	... ...	3·0 mm.

Horizons.—(I) Redhill Beds; (II) Slade Beds.

Localities.—(I) Redhill Quarry; (II) Quarry at Upper Slade.

Bellerophon (Sinuites) crypticus, sp. nov. (Pl. XX, Figs. 12–14.)

Shell involute, closely coiled, subglobose, sides somewhat flattened, greatest thickness at umbilicus, back narrowly rounded; outer whorl completely embracing and hiding inner whorls, and increasing rather rapidly in size to mouth; umbilicus minute (exposed in casts); section of whorls semi-elliptical to parabolic; aperture higher than wide, not expanded laterally; outer lip thin; inner lip more or less reflexed and thickened; dorsal sinus moderately deep, broadly V-shaped; apertural lobes rounded gently to sinus, where margin is rather suddenly and sharply curved inwards. Surface of

[1] Ulrich: op. cit., p. 828.
[2] Lindström & Angelin: Fragmenta Silurica (1880), p. 15.
[3] Ulrich: op. cit., p. 832, pl. lxi, figs. 14, 15.
[4] Billings: Palæoz. Foss. Canada, vol. i (1865), p. 346, fig. 334.
[5] Ulrich: op. cit., p. 835, pl. lxi, figs. 24, 25.

shell ornamented with rather strong concentric growth-lines and ridges on apertural lobes, and generally with one rather strong, broad constriction a little inside margin of mouth; general surface of shell ornamented with a minute, regular cancellation composed of equal-sized, fine, revolving striæ closely placed and crossed by similar transverse, slightly flexuous striæ.

Dimensions:

Height (average)	...	...	about 20 mm.
Diameter ,,	...	...	,, 8–10 mm.

Horizons.—(I) Redhill Beds; (II) Slade Beds (?).

Localities.—(I) Prendergast Place and Lane; (II) lane near Crundale, and Robeston Wathen.

Remarks.—The specimens of this shell are usually only preserved as internal casts, which are generally somewhat crushed and distorted. In a few instances the aperture and external ornamentation are fairly well seen. It is a rather abundant fossil in the Redhill Beds, but examples in anything approaching a perfect condition are rare.

The close resemblance of this form to the well-known but frequently misunderstood *Bellerophon bilobatus*, Sow.,[1] is obvious, and it undoubtedly belongs to the same group of species, which was named *Sinuites* by Koken (1896),[2] and subsequently *Protowarthia* by Ulrich (1897)[3] in apparent ignorance of Koken's name, the former choosing *B. bilobatus* as the type and the latter *B. cancellatus*, Hall, which has frequently been regarded as identical. Our shells, however, differ from typical examples of Sowerby's species in having a more narrowly rounded back, a less subquadrate section of the whorls, a less broad and less globose shell, a more rapidly increasing outer whorl, and a constriction near the mouth. The fine cancellation of the surface, though not mentioned or figured by Sowerby in his original description of *B. bilobatus*, was observed by McCoy[4] and Salter[5] in specimens which they attributed to that species. Koken's[6] *Sinuites bilobatus*, mut. *macer*, may be identical with our form, but his description is too brief, and no figure has been published. Portlock's *B. bilobatus*,[7] var. *compressus*, is founded on too crushed a specimen to determine its original shape and characters. But his *B. elongatus*[8] closely resembles our Redhill form in shape, though certainly devoid of the peculiar fine cancellation on the surface. Through the kindness of Dr. Kitchin I have had access to Portlock's types, and it is much to be regretted that they are in such a wretched state of preservation that his specific names are practically worthless. Accordingly, I feel

[1] Sowerby: in Murchison's Silur. Syst., p. 643, pl. xix, fig. 13.

[2] Koken: Die Leitfossilien (Leipzig, 1896), p. 392; id., Bull. Acad. Imper. Sci. St. Petersb., ser. v, vol. vii (1897), No. 2, p. 117.

[3] Ulrich: op. cit., pp. 848, 867.

[4] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus. (1854), p. 309.

[5] Salter: Cat. Camb. Silur. Foss. Woodw. Mus. (1864), p. 67.

[6] Koken: Die Leitfoss., p. 393; id., Bull. Acad. Imper. Sci. St. Petersb., ser. v, vol. viii (1897), No. 2, p. 118.

[7] Portlock: op. cit., p. 397, pl. xxix, figs. 2*a*, 2*b*.

[8] Ibid., p. 397, pl. xxix, figs. 4*a*, 4*b*.

justified in giving a new specific name to this Haverfordwest fossil, as its characters are well marked, though individual specimens showing all of them are rare.

There can be no doubt that Koken's and Ulrich's groups *Sinuites* and *Protowarthia* are completely synonymous. The earlier classification and group typified by *B. bilobatus*, which Koken proposed in 1889,[1] were abandoned by him in 1896 and rejected by Ulrich in 1897. Koken's subsequent definition of *Sinuites* is much shorter than that given by Ulrich for *Protowarthia*, and he is doubtful about the distinction of the species which he mentions. The diagnosis is as follows:—"Mündung mit breiter Bucht, die kein Schlitzband hinterlässt. Nabelgegend mit nach vorn abgegrenzter Runzelschicht. Aussenseite der Windungen innerhalb der Mündung mit derben Runzeln. Nabel verdeckt. *Bellerophon bilobatus*, Sow." Ulrich defines *Protowarthia* as follows:—"Aperture large, but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus, but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striæ. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl, and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines. Type, *Bellerophon cancellatus*, Hall." The ornamentation of *B. cancellatus*[2] is indistinguishable from that of our form, but Ulrich denies that this species is identical with *B. bilobatus*, Sow., and considers that his *Protowarthia obesa*[3] should rather be compared with it.

Bellerophon (?) multirugatus, sp. nov. (Pl. XX, Figs. 11, 11*a*.)

Fragments of a large *Bellerophon*-like shell occur in the Redhill Beds of Prendergast Place and Mill Lane with peculiar characters which mark it off from all the other species. The shell seems to be involute, with the outer whorl embracing the inner ones and the umbilicus absent or minute; the back is broad with a low but distinct carina, but apparently no slit-band; the outer whorl enlarges rapidly towards the mouth, which is transversely expanded and has a reflexed inner lip. The margin of the mouth is not preserved, so that the sinus, if present, cannot be seen. The shell is specially remarkable for its ornamentation, which consists of regularly-arranged, strong, subequal, rounded to subangular, broad, transverse ribs, separated by shallow grooves of the same width. These ribs curve backwards towards the keel, over which they pass without interruption, the opposite ones uniting in a broad V enclosing an angle of about 150°. The ribs die out on the expanded margins of the mouth, and are weaker on the lower sides of the whorls. Fine, spiral, revolving, equidistant striæ cross the

[1] Koken: Neues Jahrb. f. Mineral., Beil., Bd. vi (1889), p. 377.
[2] Hall: Palæont. N.Y., vol. i (1847), p. 307. Ulrich: op. cit., p. 872, pl. lxiii, figs. 1–14.
[3] Ulrich: op. cit., p. 874, pl. lxiii, figs. 45–47.

ribs parallel to the keel, but become sinuous, broken, and irregular near the mouth. The shells are mostly crushed, but must have reached a rather large size, some measuring 50–70 mm. across the mouth. The true position and affinities of this form are doubtful.

BELLEROPHON (BUCANOPSIS) SECUNDUS, sp. nov. (Pl. XX, Figs. 15, 15*a*.)

Shell subglobose, with broad, rounded back; of few volutions; whorls transversely subquadrate in section, broader than high; umbilicus moderately large, deep, with subangular margins, exposing inner whorls; aperture transverse, more or less expanded; inner lip reflexed on inner end of last whorl; band rather broad, with narrow, raised margins, not depressed, with fine, gently curved lunulæ; surface of shell on each side of band marked with rather strong, regular, straight, parallel, subequal, revolving raised lines, about 24 in number, closely crowded near band, but becoming more widely separated laterally, crossed at right angles by very fine, transverse, slightly wavy striæ.

Dimensions.—Height about 15 mm.

Horizon.—Redhill Beds.

Localities.—Prendergast Place and Lane.

Remarks.—The true generic position of this species in Ulrich's classification seems to be in *Bucanopsis*.[1] But our specimens are so crushed and distorted that it is upon the characters of the ornamentation and slit-band that we must chiefly depend; and these are sufficiently definite and important to mark the species.

The term *Bucania* is employed by Ulrich in a much more restricted generic sense than Hall originally intended, and than later authors (Waagen, Koken, etc.) have used it, and some of the species now placed in *Bucanopsis* have been included in it by them. Ulrich points out that in *Bucanopsis* the spiral surface-markings are straight and parallel with the direction of the whorls, while in *Bucania* sens. str. they are wrinkled, interrupted, and more or less oblique in direction. He would provisionally include in *Bucanopsis* all the Palæozoic spirally striated shells which agree in other respects with *Bellerophon*. The type is *B. carinifera*, Ulrich, from the Trenton Group.[2] The full definition of the genus is as follows: "Shells agreeing in all respects with *Bellerophon*, excepting that their surfaces are cancellated by regular, revolving, and transverse striæ. The volutions enlarge rapidly, giving a broadly expanded aperture; the umbilicus is of moderate size, and may be closed entirely, while the inner lip is always somewhat thickened. The revolving lines are never oblique nor wrinkled."

Our Redhill species may be compared with the type species, which is the only Ordovician form previously known; but the band appears to be less prominent and the back broader, and the spiral lineation slightly different.

[1] Ulrich: op. cit., pp. 853, 922.
[2] Ulrich: op. cit., p. 925, pl. lxii, figs. 56–61.

CONRADELLA (?) sp. (Pl. XX, Figs. 5, 5*a*, 5*b*.)

There is a small shell occurring in some abundance in the Slade Beds of Upper Slade which may possibly belong to the genus *Conradella* established by Ulrich,[1] but its state of preservation is not quite satisfactory. It seems to consist of a few rapidly enlarging whorls coiled in the same plane, like *Cyrtolites*; the whorls are higher than wide and more or less sharply carinated on the back, below which they are somewhat compressed, swelling out to their maximum diameter near their middle. The keel appears to carry a slit-band crossed by rather distant, strong lunulæ. The ornamentation consists of rather coarse, raised, fimbriated lines, equidistant and equal in size, and connected by less prominent, short, straight lines at right angles to them and alternately arranged, so as not to form true revolving spirals. No other details can be made out. The ornamentation recalls that found in *C. Dyeri*, var. *cellulosa*, Ulrich,[2] and the shape is apparently similar. The height of our little shells averages about 6 mm.

Horizon.—Slade Beds.

Locality.—Upper Slade, Haverfordwest.

EXPLANATION OF PLATE XX.

FIG.

1. *Eotomaria Robertsi*, sp. nov. Impression of exterior of shell. × 2. Redhill Beds, Prendergast Place, Haverfordwest.
2. Ditto. Side view of internal cast of another specimen. × 1½. Same horizon and locality.
2*a*. Ditto. Base of same specimen. × 1½.
3. Ditto. Base of another specimen, showing reflexed lip. × 1½. Same horizon and locality.
4. Ditto. Internal cast of a young individual. × 4. Redhill Beds, Prendergast Mill Lane.
5. *Conradella* (?) sp. × 4. Slade Beds, Quarry at Upper Slade.
5*a*. Ditto. Transverse section through shell.
5*b*. Ditto. Portion of surface of same specimen enlarged to show ornamentation. × 8.
6. *Lophospira* cf. *turrita*, Portlock. × 2. Slade Beds, lane between Slade Hall and Pelcombe Bridge.
6*a*. Ditto. Band of same specimen enlarged. × 5.
7. *Liospira* sp. × 2. Redhill Beds, Prendergast Place, Haverfordwest.
7*a*. Ditto. Same specimen, viewed from above. × 2.
8. *Archinacella Prendergasti*, sp. nov. Top view. × 1½. Redhill Beds, Prendergast Place.
8*a*. Ditto. Side view of same specimen. × 1½.
9. Ditto. Another specimen, laterally compressed. × 1½. Same horizon and locality.
10. *Archinacella* aff. *rotunda*, Ulrich. Top view. × 3. Redhill Beds, Redhill Quarry.
10*a*. Ditto. Side view of same specimen. × 3.
11. *Bellerophon* (?) *multirugatus*, sp. nov. Crushed and distorted specimen. × 1½. Redhill Beds, Prendergast Mill Lane.
11*a*. Ditto. Portion of back of same specimen enlarged to show ornamentation. × 4.

[1] Ulrich: op. cit., p. 904.
[2] Ulrich: op. cit., p. 910, pl. lxvii, figs. 27–29.

12. *Bellerophon (Sinuites) cryptieius*, sp. nov. Side view of internal cast. × 1½. Redhill Beds, Prendergast Place.
12*a*. Ditto. Dorsal view of same specimen. × 1½.
13. Ditto. Another specimen, showing apertural margin and reflexed lip. × 1½. Same horizon and locality.
13*a*. Ditto. Portion of surface of same specimen enlarged to show ornamentation. × 5.
14. Ditto. Portion of another shell, showing apertural margin and dorsal sinus. × 1½. Same horizon and locality.
15. *Bellerophon (Bucanopsis) secundus*, sp. nov. Dorsal view of imperfect specimen. × 1½. Redhill Beds, Prendergast Place.
15*a*. Ditto. Portion of back of another specimen enlarged, showing band and ornamentation. × 1½. Same horizon. Prendergast Mill Lane, Haverfordwest.

IV.—On a Section of Middle and Upper Lias Rocks near Evercreech, Somerset.

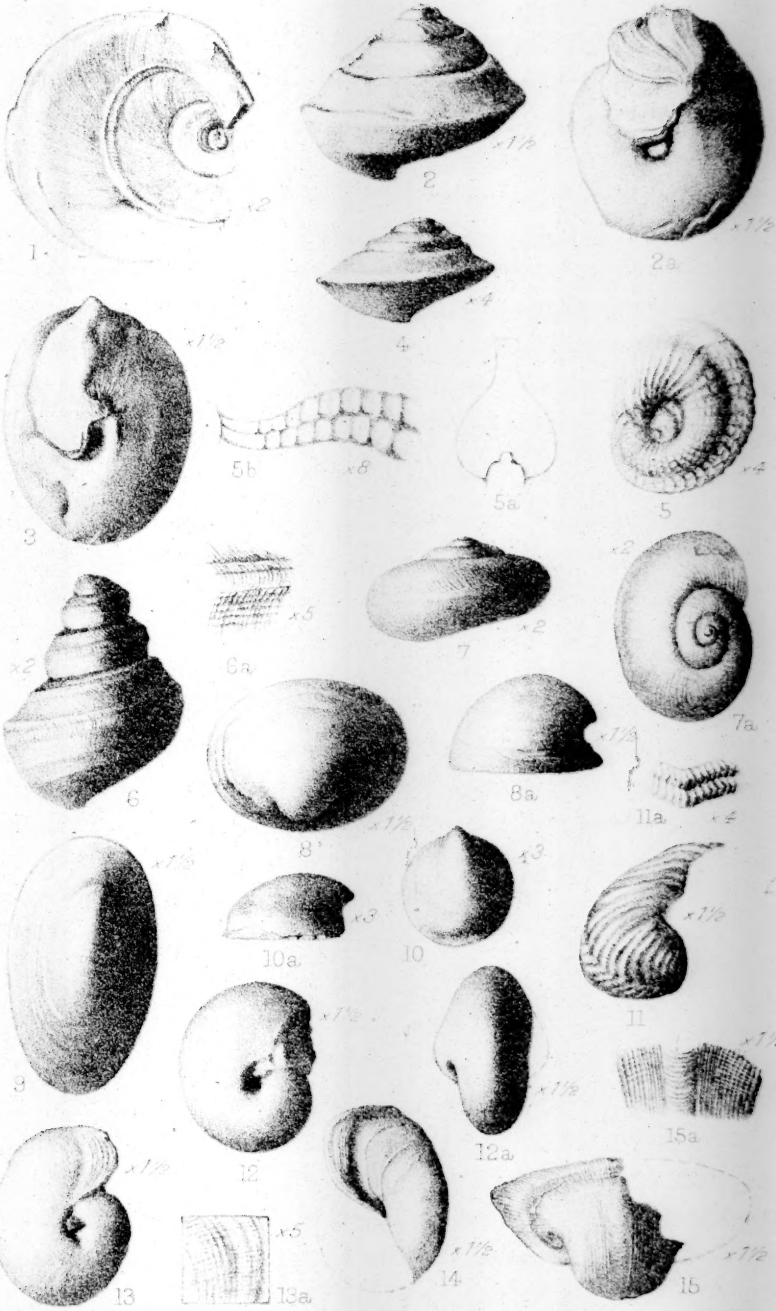
By L. Richardson, F.G.S.

DURING a brief survey of the Inferior Oolite in the neighbourhood of Doulting, Somerset, in 1905, I visited a disused quarry on the hill a mile and a half north of Evercreech, and situated where the boundary-line between the Inferior Oolite and Midford Sands is shown on the Geological Survey Map, Sheet xix. I was surprised to find that instead of the somewhat massive rock exposed in the quarry being Inferior Oolite, it was Marlstone, capped with Upper Lias clays and limestones. Since the section is becoming rapidly overgrown, it appears desirable to record the details obtained for the benefit of those who will survey the district in the future for the New Series Maps.

Quarry near Evercreech.

			ft.	ins.	
Upper Lias (Toarcian).	*bifrontis*.	1. Clay, brown and bluish.			
		2. Limestone, dark-green, earthy, with dark-yellow specks resulting from the decomposition of the ferruginous granules ...	1	4	*Hildoceras bifrons* (Brug.), *Dactylioceras* cf. *Hollandrei*, Wright, *non* D'Orb., *Rhynchonella* cf. *jurensis* (Quenstedt), and *Pecten substriatus*, Roemer.
	fibuliferi.	3. Limestone, brownish-grey, with a few ferruginous granules 2 in. to 6 in.	0	4	
		4. Clay, dark-purplish ... about	1	6	
		5. Limestone, brownish-grey, somewhat earthy, but hard in places, devoid of ferruginous granules	0	2½	*Polyplectus capellinus* (Quenstedt), *Cryptaulax scobina?* (Deslongchamps).
		6. Clay, grey and brown	0	4	
Middle Lias (Pliensbachian).	*spinati*.	7. Limestone, pale-brown, ironshot	0	3	*Paltopleuroceras spinatum* (Brug.).
		8. Clay, brown	0	3	
		9. Limestone, hard, dark, ironshot, top layer crowded with belemnites ... ... (seen)	10	0	*Belemnites paxillosus*, Schlotheim, *Terebratula punctata*, Sow., *Rhynchonella tetrahedra* (Sow.), *Cypricardia pellucida*, Moore (= *C. intermedia*, Moore).

I am indebted to Mr. S. S. Buckman for approximately identifying the ammonites. The precise date of beds 3 and 4 could not be



G. M. Woodward del. et lith. West, Newman imp.

Ordovician Gastropoda from Haverfordwest.

ascertained, but the limestone-band agrees in lithic structure with bed 5 rather than with 2, hence I have provisionally grouped it with the *falciferum*-deposits. The clay overlying the rock of *spinati* hemera occupies the stratigraphical position of the *acutum*-bed.

On the Geological Survey Map the Middle Lias is shown to occupy a narrow zone on both sides of the valley running north from Batcombe; but westwards, in the neighbourhood of Chesterblade, it was thought to be overlapped by the Midford Sands; in other words, that the 'Sands' rested directly and non-sequentially upon the Lower Lias. This, however, is not the case: the Marlstone is well-developed, but how much farther north it extends I was unable to find out. Probably in that direction the Middle Lias is overlapped by the Upper Lias clays, and these in turn by the Inferior Oolite.

In considering the geographical distribution of the component beds of the Liassic and Inferior-Oolite Series, it is necessary to bear in mind that in tracing the beds from south to north we are approaching a tract of country, the Mendips, along which (there is ample evidence) movements of subsidence and elevation have occurred time after time. Beds may have been deposited, uplifted, and partially or wholly eroded. Thus, although the Marlstone is present in this quarry at Mays Down, a mile and a half to the north of Evercreech, it by no means follows that it extends as far north as Doulting. It may be present there; or it may have been deposited, elevated, and removed. Likewise with the Midford Sands. In the railway-cutting at Doulting, the peculiar conglomeratic limestone forming the base of the Inferior Oolite rests directly upon bluish, micaceous, and arenaceous clays, from which water is thrown off. Thus there is no deposit there worthy of the name of 'Sands.'

REVIEWS.

I.—The Dead Heart of Australia: A Journey around Lake Eyre in the Summer of 1901–1902, with some account of the Lake Eyre Basin and the Flowing Wells of Central Australia. By J. W. Gregory, D.Sc., F.R.S., F.G.S., Professor of Geology in the University of Glasgow. 8vo; pp. xvi and 372, with 38 illustrations and maps. (London: John Murray, 1906. Price 16*s.* net cash.)

PROFESSOR GREGORY has just presented us with a most interesting volume of travels in the interior of Australia, dealing with the geology and physical geography of the Lake Eyre region, and giving most graphic and lively descriptions of the 'Aboriginee' at home. Those who recall the author's African experiences as given in his history of "The Great Rift Valley"[1]

[1] See Geol. Mag., 1896, Dec. IV, Vol. III, pp. 324–327, Pl. XI.

(1896) will enjoy the perusal of this new book with even greater pleasure than the last.

The Australian Continent may be not unfitly compared to the trunk of one of those 'Giant trees' of the Sierra Nevada, or the equally colossal 'Australian gum-trees,' whose age may be reckoned by at least twenty centuries, their centre dense and almost inanimate, but the periphery alive and growing still, receiving beneath its bark a ring of new tissue year by year.

Once the centre of the great Australian Continent throbbed with the vigorous circulation of youth; animals abounded over its vast and well-wooded plains: now all is arid and apparently waterless; only along its external border do we find that energetic display of vitality which marks the living world. Its heart, like that of the great *Sequoia* or the giant *Eucalyptus*, has, seemingly, almost ceased to pulsate; but down, deep down, beneath the surface of its dried-up plains, vast springs of sweet waters exist, and may still be reached, like the invisible sap-flow of the 'big trees,' rich in stored-up supplies of life-giving energy, which need only to be touched, as was the stony rock of old—not by the magic rod of any modern water-finding Moses, but by the practical, intelligent 'artesian well-borer'—to make it overflow at the surface, and bring back again abundant vegetation and animal life to its now arid and deserted plains.

Let us, however, make way for the author, and he will tell us in his own words "how the 'Kadimakara' came down from the skies." The story is delightful, and has all the freshness of novelty to recommend it:—

"According to the traditions of some Australian aborigines, the deserts of Central Australia were once fertile, well-watered plains. Instead of the present brazen sky, the heavens were covered by a vault of clouds, so dense that it appeared solid; where to-day the only vegetation is a thin scrub, there were once giant gum-trees, which formed pillars to support the sky; the air, now laden with blinding, salt-coated dust, was washed by soft cooling rains, and the present deserts around Lake Eyre were one continuous garden.

"The rich soil of the country, watered by abundant rain, supported a luxuriant vegetation, which spread from the lake-shores and the river-banks far out across the plains. The trunks of lofty gum-trees rose through the dense undergrowth, and upheld a canopy of vegetation, that protected the country beneath from the direct rays of the sun. In this roof of vegetation dwelt the strange monsters known as 'Kadimakara' or 'Kadimerkera.'

"Now and again the scent of the succulent herbage rose to the roof-land, and tempted the inhabitants to climb down the gum-trees to the pastures below. Once, while many Kadimakara were revelling in the rich foods of the lower world, their retreat was cut off by the destruction of the three gum-trees which were the pillars of the sky. They were obliged to roam on earth, and wallow in the marshes of Lake Eyre, till they died, and to this day their bones lie where they fell. After the destruction of the gum-trees the small holes in the

forest-roof increased in number and size, until they touched one another, and all the sky became one continuous hole; wherefore the sky is called 'Puri Wilpanina,' which means 'Great Hole.'

"At times, when the country is wasted by prolonged drought, or the floods from the Queensland hills lie too long upon the hunting-grounds, the aborigines make pilgrimage to the bones of the Kadimakara. There corroborees are held, at which blood sacrifices are offered and dances performed to appease the spirits of the dead Kadimakara, and persuade them to intercede with those who still dwell in the sky and control the clouds and rain.

"This legend is part of the folk-lore of the Dieri, a tribe found in the country along Cooper's Creek, eastward of Lake Eyre. The same legend is told by other tribes in the same district of Central Australia, with variations in the form of names and in other details. It may have arisen as a pure fiction, invented by some imaginative, story-telling native, to explain why large bones are scattered over the bed of Cooper's Creek. It may, on the other hand, be a shadowy reminiscence of the geographical conditions which existed in some distant ancestral home of the aborigines, or of those which prevailed in Central Australia at some remote period.

"What geographical conditions, it may be asked, could have given rise to such a legend?

"To the dweller in the open down or moorland, the idea that the vault of heaven could be upheld by trees, or that the open, transparent sky could support heavy animals of flesh and bone, seems the idlest fancy. But to a man who knows the tropical forest, it appears inevitable that the first attempts by primitive forest-people to explain the world around them must closely follow the lines of the Kadimakara legend.

"If the pygmies of the East African forests have any theory of the limited universe known to them, they probably regard it as a two-storied structure in which they occupy the lower floor. They live in a jungle of bamboos and dense undergrowth, while high above them is a thick, felted layer of foliage and creepers, upheld by the trunks of lofty junipers, which rise straight to a great height before they branch. The tangled layer of vegetation overhead deprives the natives of any knowledge of the world above the tree-tops. They are covered by a sheet as opaque and as continuous as a roof slightly out of repair. In that roof live monkeys and birds and beasts, that never descend to the ground below; while the animals that live and move and have their being in the undergrowth are equally cut off from the world above. The primitive hunter has some slight knowledge of the jungle roof above him. He hears the harsh halloa of the colobus, the shrill cry of the birds when they fall a prey to snakes or monkeys; his keen eye can detect the prized fur of the colobus despite its close resemblance to the long, hanging masses of grey bearded lichen that drape the black branches of the trees. But the dweller in the underlying jungle knows nothing of the region above the tree-tops. In the dry season, when the forest is not covered in mist, he may see the stars slowly crossing the holes in the roof; but

he knows nothing of their distance, and probably thinks of them only as fire-flies with an unusually slow and steady flight. The roof above him is his highest heaven, which supplies him the rain that drips heavily from the sodden foliage. The occasional fall of a dead bird or a monkey is to him as much a gift from the gods as were the sky-stones that supplied the Siberians and Eskimo with iron. The change from the dark of night to the dull gloom that pervades the lower forest at midday is clearly due to some change in or above the roof. But the forest-dweller has no clue to distance, so he flattens the whole universe above him into one solid floor, supported by the tree-trunks, just as the Greeks projected all the star-zones into one solid firmament.

"Those who interpret the Kadimakara legend by the light of a knowledge of tropical forests, naturally see in it either a reminiscence of the time when the geographical conditions of Central Australia were different from those that prevail at present, or a reminiscence of the country whence the aborigines migrated to Australia. If, therefore, the geologist can determine whether the bones of the extinct monsters of Lake Eyre[1] correspond to those described in the aboriginal traditions, he can throw light on several interesting problems. If the legends attribute to the extinct animals characters which they possessed, but which the natives could not have inferred from the bones, then the legends are of local origin. They would prove that man inhabited Central Australia at the same time as the mighty *Diprotodon* and the extinct giant kangaroos. If, on the other hand, there is no such correspondence between the legends and the fossils, then we must regard the traditions as due to the habit of migratory peoples of localising in new homes the incidents recorded in their folk-lore.

"The geologist may therefore hope to help the student of the Australian aborigines by explaining some of their traditions, by throwing light on their migrations, and by showing the date of their arrival in Australia."

Part ii (pp. 17–142) of Dr. Gregory's book is devoted to the narrative of the expedition, which gives the reader a very good insight into desert travelling with camels and native guides, and the joys and sorrows of dust- and rain-storms, water-holes, and soakages, and the finding of *Diprotodon* bones, etc., also some excellent traits in character amongst the natives.

Part iii (pp. 145–267) gives us an interesting description of the Lake Eyre Basin, "The Dead Heart of Australia," the charm of desert life, a good deal about the 'Aboriginee' of Lake Eyre, and how the present condition of the lake has come to pass.

Part iv (pp. 271–352) treats of the chances of the revival of the 'Dead Heart' of Australia, of its subterranean waters, the nature of flowing wells, the great east-central artesian basin, why the water rises in the Australian wells, and many wise observations, based on careful geological study; much also as to the error (common throughout the country) of assuming the *permanent* nature of the

[1] The *Diprotodon*, the giant species of kangaroos, and the *Genyornis*.

supply from artesian sources, and the danger consequent upon the present wanton waste of such water at the surface. A chapter is devoted to the gigantic proposal to flood Lake Eyre from the sea; but a few carefully prepared statements given (on p. 347) by Mr. A. S. Kenyon, Sir Charles Tod, and others, show the futility of such an attempt, at least so far as human agency is concerned. At p. 148 Dr. Gregory gives us an epitome of the changes that must have taken place in this inland sea basin.

The region of Lake Eyre in Secondary (Jurassic) times must have been slowly sinking till it was flooded by the sea, which steadily encroached from the Gulf of Carpenteria in the north to Stuart's Creek and Lake Torrens in the south.

The sea subsequently retreated, and the great basin of Central Australia again became land. A great uplift then occurred in Eastern Queensland. The sea, after withdrawing from Northern Australia, began to encroach upon the south, covering much of what are now the coast lands of South Australia and Victoria, and extended in gulfs thence far inland, especially up the Murray, so that the Darling, the Murrumbidgee, and the Hume entered the sea as independent rivers.

The earth-movements which followed impressed upon South Australia its main existing geographical features. The great valley of South Australia was formed. The lower part of this valley foundered beneath the sea and formed Spencer's Gulf, the northern became the long basin of Lake Torrens.

The Lake Eyre country also began again to sink, till the lake-margin was, as now, thirty-nine feet below sea-level. Previously the rivers, which now flow towards Lake Eyre, flowed south-eastward to the Darling or had an independent course to the sea, which then ran up the Murray River. As the depression of Lake Eyre continued, the Cooper and the Diamantina were diverted to its basin, where they accumulated as a vast inland sea. Round such a sheet of water there must have been a heavy dew, and probably also the rainfall was considerable, for the adjacent steppes were well grassed and fertile, and large trees—now represented by their petrified trunks—grew on the plains. The water of this lake was fresh . . . . and was probably at least three times the size of its present bed, and on its shores lived many giant kangaroos, giant wombats, as well as wallabies, bandicoots, and marsupial rats.

Crocodiles swarmed in the lake and its estuaries, and preyed upon the primitive Queensland mudfish (*Ceratodus*) and on huge bony fish, all of which have long since disappeared from the waters of the Lake Eyre basin. This condition of affairs did not endure. The rainfall dwindled, the water-level sank, and the lake decreased in size; the discharge from the lake could no longer keep open its channel, and Lake Eyre lost its outlet; its waters were henceforth removed by evaporation; the mineral matters carried into the lake by the rivers were concentrated until the waters became salt, and the fish and crocodiles were all destroyed. As the lake shrank in area, less and less rain fell upon its shores; the vegetation withered; the once

green succulent herbage was replaced by dry spiny plants; the giant marsupials died of hunger and thirst; hot winds swept across the dusty plains, and the once fertile basin of Lake Eyre was blasted into desert (p. 151).

As to the flooding of Lake Eyre, the distance to Port Augusta (at the head of Spencer's Gulf) is 260 miles, and the surface of Lake Eyre is 39 feet below sea-level; this would give a fall of one inch and a fifth to the mile to a canal, so that the water would doubtless flow through such a channel. It is the enormous loss by evaporation which offers the most insuperable obstacle to any project for the improvement of this great area.

"The quantity of water carried into Lake Eyre by the Diamantina and the Cooper is enormous. The Diamantina rushes along like a mill-race; the Cooper flows in a broad sheet, in places twelve miles wide; and both rivers sometimes flow for months. Nevertheless, though the southern part of Lake Eyre frequently holds water, no man has yet seen the lake either full or nearly full. And if these two large rivers cannot fill Lake Eyre basin, a sluggish fifty feet wide canal would be as successful as a Melbourne water-cart trying to induce one of its broad thoroughfares to lie quiet in a dust-storm" (p. 349).

We should like to give our readers a specimen of the author's vivid descriptions of the Australian natives; space does not, however, admit; but they must certainly get the book and read about the so-called 'Aboriginee.' We feel sure that those who take up Dr. Gregory's book will not lay it down again until they have read it through, and that they will enjoy it in the process as thoroughly as we have done.

II.—Geology: Processes and their Results. By T. C. Chamberlin and R. D. Salisbury. pp. xix and 654. with 24 plates (maps) and 471 text-figures. (London: John Murray, 1905. Price 21*s.* net.)

THE first volume of this new Textbook of Geology by Professors T. C. Chamberlin and Rollin D. Salisbury, of the University of Chicago, strikes us as a serious and conscientious attempt to grapple with the first principles of earth-knowledge in its entirety, and the attempt has been as successful as any such comprehensive attempt can expect to be. Everything is classified and well ordered, and the essence of the available information on the various branches of the subject is condensed into pithy generalized statements with only just sufficient exemplification to illustrate the argument. Everywhere we are made to feel that the work is the product of men with a practical grasp of their material, who have striven to express in their own way all that they have learnt. Therefore this is not a textbook made in the too frequent way, "as apothecaries make new mixtures, by pouring out of one vessel into another." We find in consequence that even when the authors lead us over familiar ground we are frequently brought to fresh view-points. It must be

admitted, however, that sometimes the new aspect has no particular advantage over the old, and indeed is less impressive. For the matured geologist the discussion of difficult problems by the method of "multiple hypotheses," elsewhere advocated by the senior author and here adopted, has many advantages; but it may be doubted whether the method will commend itself to the geologist in the making, for whom a single aspect of an uncertain question is usually more than sufficient. The book, in fact, possesses the characteristic of much American geological literature, in uniting a mass of simple elementary matter with discussions that demand wide-reaching knowledge of the facts of the science for their proper appreciation. As the authors state, however, that while the work is intended primarily for mature students, it has been framed also for the reader without systematic antecedent knowledge of the subject, the combination of elementary and advanced material is, in this case, unavoidable. Some of the problems raised in the book—as, for example, the discussion of the original composition and internal structure of the earth and its relation to the origin of the igneous rocks and volcanoes; that relating to the geological history of the atmosphere; and that dealing with the physics of glacier-movement —embody recent views of the senior author which necessitate considerable modifications in the prevalent conceptions of geological physics. Into these abstruse questions we shall not venture to enter, but we heartily commend them to the attention of philosophical geologists, who will find them conveniently brought together and summarized in this book. All that we can attempt is briefly to indicate the contents of the volume.

The work begins boldly with a "Preliminary Outline" (chap. i, pp. 1–19), which, under the heading of "Astronomic Geology," starts by considering the earth as a planet, with a discussion of the astronomical conditions that may have produced geological effects. Next, under "Geognosy," the atmosphere, hydrosphere, and lithosphere are successively outlined, their relative proportions illustrated by some striking numerical data, the relation of the ocean basins to the land-surfaces discussed, and the origin of the rock-masses tersely indicated. In chap. ii (pp. 20–52), dealing with "The Atmosphere as a Geological Agent," the work of the wind is fully considered, along with other atmospheric effects, including even the occasional influence of lightning.

Then follows the longest and most richly illustrated chapter in the book (chap. iii, pp. 53–201), on "The Work of Running Water," wherein all the recent ideas with respect to physiographic development are conveniently brought together and supported by appropriate examples from all parts of the United States. The broad generalizations on this subject are illustrated by some geometrical and other designs (figs. 45–51) of remarkable aspect, that look as though they had wandered out of textbooks of crystallography and biology. In the next chapter (iv, pp. 203–231) "The Work of Ground- (Underground) Water" receives treatment, the solvent and other effects of such waters being duly considered.

The chapter (v, pp. 232–308) on "The Work of Snow and Ice" contains much information that has not hitherto filtered into geological textbooks, and is embellished, both pictorially and verbally, with the results of the authors' personal observations in North Greenland. We note that the thickness of the Greenland ice-dome at its centre is estimated at 5,000 feet or more, and we recommend the statement to the attention of the writer in this Magazine (March, 1906, p. 120) who has recently, on hypothetical grounds, revived the idea that ice cannot attain a greater thickness than about 1,600 feet. The discussion of the physics of ice-movement in this chapter contains much new and suggestive matter.

"The Work of the Ocean" is dealt with in chap. vi (pp. 309–374), and this, we think, is one of the weaker chapters of the book. In adhering to their plan of selecting pictorial illustrations chiefly from American sources, the authors fall back upon examples from the beaches and cliffs of the great lakes, although these are not marine and lack the essential feature of a tidal flat. But it is indeed remarkable how small is the proportion of sea-cliff in the coastline of the United States.

The account of "The Origin and Descent of Rocks" in chap. vii (pp. 375–462) covers a very wide range, and contains some original features. Divided like the rest into numerous sections, subsections, and titled paragraphs, it begins with an outline of the chemical conceptions regarding rock-structure and molten magmas, and next discusses the varied products derived from these magmas by cooling under different conditions. In describing the "general names"—greenstone, trap, basalt, etc.—that may be applied to igneous rocks, it is stated that the name 'trap' "refers to the step-like arrangement which the edges of the superimposed sheets of lava often take" (p. 399), but this statement as it stands seems somewhat misleading, as it might be taken to imply that the step-like arrangement in question was originally present, instead of being, in most cases, produced during subsequent denudation.

The 'secondary' (a somewhat ambiguous term for the 'sedimentary') rocks are then dealt with; after which we are led to the consideration of the 'internal alterations' of rocks, especial attention being given to 'carbonation and decarbonation,' to which processes one of the authors, as is well known, ascribes wide-reaching results. The processes as a whole are classed as 'descensional' and 'reascensional,' the former being those concerned in the breaking down of rocks, and the latter those concerned in their renovation. An outline is then given (in smaller type) of the new system of rock-classification and nomenclature proposed by American petrographers, and the chapter ends with a discussion of ore-deposits. As the book is remarkably free from printers' errors, we may call attention, in passing, to "the surface-water shave" on p. 459.

The chapter (viii, pp. 463–501) on "Structural (Geotectonic) Geology" does not particularly impress us, and seems to lack

balance. For example, the abnormally symmetrical calcareous concretions, though very curious and though beautifully illustrated in figs. 371–373, are not of sufficient geological consequence to deserve the two pages of the textbook devoted to them, and the same remark applies to the septarian nodules, figs. 375–377, while such an important feature as the igneous dyke is illustrated by a sand-filled fissure which is not a true dyke.

In the statement on p. 478—"Since the strike is always at right angles to the dip, the strike need not be recorded if the direction of dip is. Thus dip 40°, S. 20° W. is the same as dip 40°, strike W. 20° N."—it seems to be forgotten, in the last sentence, that the dip may be away from the strike-line in two directions. The definition of an isoclinal fold takes the form of a simple reference to a figure (fig. 393), which shows the beds folded vertically—surely a misleading and insufficient definition for the student! We thought that the term 'pitch' had been introduced and adopted in America to express the inclination of the crests and troughs of folds; but we find on p. 483 that a circumlocution, introducing the word 'plunging,' is used in this sense.

In the next chapter (ix, pp. 502–562) on "The Movements and Deformations of the Earth's Body (Diastrophism)" the authors again take a stimulative plunge into the philosophical aspects of the science. Earthquakes and their effects are discussed at some length; and then the 'slow massive movements' are brought under consideration, including the 'nearly constant small movements' or gentle warpings, the 'great periodic' or 'mountain-forming' movements, and the 'plateau-forming' and 'continent-forming' movements. Some suggestive ideas are broached in comparing the relative values and effects of these various deformations; and then we are carried deeply into hypothetical physics in speculating upon the causes of movement and the probable condition of the earth's interior. In this, and in the following chapter (x, pp. 563–607) on "The Extrusive Processes," free play is given to the method of 'multiple hypotheses' already alluded to; and among these hypotheses the theory of the growth of the earth by solid accretion, recently brought forward by the senior author, receives full consideration and leads to the introduction of some novel ideas, whose appraisement must be left to the physicist. He will be a tough student, and far removed from the average hammer-wielder, who shall set himself conscientiously to fathom the profundity or otherwise of these speculations.

The discussion of terrestrial vulcanism (with a side-glance at the mountains of the moon) includes a description of the different types of eruptive activity and their products; and it closes with a review of seven different hypotheses, arranged under two leading assumptions, as to the origin and mode of extrusion of lavas and their accompanying gases, the theory of accretion here receiving further development.

The final chapter (xi, pp. 608–641), dealing with "The Geologic Functions of Life," embraces a brief statement of Professor

Chamberlin's views regarding the probable fluctuations of atmospheric composition, especially in the proportion of carbon dioxide, during geological time and their effect upon climate. It also touches suggestively upon the material results of the 'mental element' in modifying the earth's surface, regarding which it is noted that "man may well be regarded not only as a potent geological agent, but as dangerously so to himself" (p. 619). The contributions of the various branches of the vegetable and animal kingdom to the geological record are set forth; and the book ends with some philosophical remarks upon the evolution, distribution, and mutual relations of organisms.

The trilobites seem to be special favourites of the authors:—"These were probably the most highly developed organisms of their times, and give the clearest hints of the stage of psychological and sociological development that had been reached when first the record of life is opened to us" (p. 632).

The authors have evidently spared no pains in the preparation of the book, which is clearly and carefully written throughout, though the style becomes somewhat ponderous and didactic at times. There is a marked absence of American idioms, and even the American methods of spelling are not obtrusive. We note, however, in at least two places, the discredited usage of 'phenomenal,' which should not occur in scientific literature. The illustrations are very numerous, well selected, and beautifully printed; and although many of them have appeared before in American geological literature, they bring a sense of breadth and freshness to the British reader wearied with the time-worn clichés of his native land. But the book is of the densest paper, and so uncomfortably heavy that even its strong neat binding cannot be expected long to stand the strain. With its two succeeding volumes of equal or still greater weight, we fear that, muscularly, the student will sometimes find the trio to be a weary load.

III.—The Coal Deposits of Batan Island, with Notes on the General and Economic Geology of the adjacent region. By Warren D. Smith, B.S., M.A., Geologist, Mining Bureau. Bulletin No. 5, Department of the Interior: The Mining Bureau, Manila. 8vo; pp. 56, and 21 plates (maps, sections, photo-micrographs of rocks and fossils). (Manila: Bureau of Printing, 1905.)

THE occurrence of coal deposits in the Island of Batan, as well as in the Philippines generally, has already been referred to by Mr. George F. Becker in his comprehensive "Report on the Geology of the Philippine Islands," published at Washington in the 21st Annual Report of the United States Geological Survey, during 1901. More detailed work has now been accomplished in Batan Island, and Mr. Warren D. Smith is to be congratulated on the very complete manner in which he has surveyed that particular area and the region immediately surrounding it. The account he presents

to us in this report includes some geographical remarks bearing upon the climate, vegetation, population, hydrography, etc. On the economic subject, particulars are given of the history of the district; the coal-seams as they occur at Liguan, Chifladura, Bilbao, and Batan; the present methods of mining, cost, labour, etc.; exploratory work on military reservation; and the classification and value of the Batan coals. Then the author passes on to a description of the general geology of the district, comprising observations on Batan Island, Rapurapu Island, Caeraray, and San Miguel, and the adjacent coast of Albay Luzon, which is followed by a more detailed statement respecting the geology of Batan Island in connection with its igneous base, the iron formation and its origin, the coal-measures, the limestone series, and the Galicia sandstones and shales. Finally, a chapter on the palæontology of Batan Island adds a further interest to the work. Three or four sets of limestone have been observed in the island rising to 1,330 feet above sea-level and 345 feet below the level of the sea: the lowest is bluish-grey and contains coral fragments, the next is more regularly bedded but with fewer fossils, whilst an uppermost limestone occurs above the coal-measures at Bilbao on Mount Bilbao and has yielded some fossils. From the highest to the lowest these limestones are said to be of coralline character, containing forms almost identical with living species. The bluish-grey material is full of Foraminiferal remains, particularly *Operculina complanata* and a Bryozoan resembling *Cellepora formosensis* of Newton & Holland (Journ. Sci. College Imp. Univ. Tōkyō, Japan, 1902, vol. xvii, article 6, pls. ii–iv, p. 6), this latter having been originally described from the Miocene formation (Orbitoidal limestone) of the Islands of Formosa and Riu-Kiu, and the former reported by the same authors as occurring in the Post-Pliocene deposits (raised coral-reef beds) of Riu-Kiu. Molluscan remains are found in the shales of the coal-measures, including a species of *Tellina*, and an *Arca* like *diluvii* of Lamarck; leaf-impressions are also met with. Further information respecting these fossils is to be given in a later memoir when more fully studied, but in the meantime the author recognises both Miocene and Pliocene rocks in Batan Island, and with regard to the age of the coal deposits he considers it possible that they may be of later age than Eocene. Microphotographs of diorite from Rapurapu and serpentine from Batan are given on plate xix; and plate xx contains similarly prepared figures of *Operculina complanata* and *Amphistegina* (?).

R. B. N.

IV.—Short Notices.

1.—Geological Survey and Museum.

WE have omitted to notice one of the most useful, interesting, and important publications of this Department, issued moreover last year. It is entitled "A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection in the Museum of Practical Geology," and it is the

work of Mr. F. W. Rudler, I.S.O., the former Curator. Clearly and concisely written, it conveys in readable form an astonishing amount of accurate information, with abundant references to further original sources of knowledge. It is especially rich in observations on the mode of occurrence, origin, and economic uses of our minerals. The volume extends to 241 pages, including a good index, and the price is 1*s*.

2. — Notes on Cambrian Faunas. By G. F. Matthew, D.Sc., F.R.S.C. Bull. Nat. Hist. Soc. of New Brunswick, vol. v, part 4, p. 406.

THIS article relates to the characters of certain Ostracoda and Trilobita of the *Paradoxides* and *Protolenus* zones of New Brunswick in Eastern Canada, and is based on additional material of species already described. There is also in this article a discussion of certain Cambrian forms from the locality at Anse au Loup, the fossils of which were studied by the late E. Billings; the opinion is expressed that the genus *Salterella* is based on ensheathed examples of *Hyolithes* and *Orthotheca*. Walcott has referred one species to *Hyolithes*; Dr. Matthew would refer the other two to *Orthotheca*.

3. — New Species and a New Genus of Devonian Plants. By G. F. Matthew, LL.D., F.R.S.C. Bull. Nat. Hist. Soc. of New Brunswick, vol. v, part 4, p. 393.

A NEW genus and new species and a mutation of a Carboniferous species from the plant-bearing strata near St. John, New Brunswick, Canada, are described in this article. The former is a fern of peculiar aspect, with thick, smooth, barren pinnules and fertile pinnules that bore pods or similar receptacles; the barren pinnules are compared with the Ginkgoale genus *Baiera* of the Secondary rocks, the fertile ones to *Palæopteris*. The other fossil described in this paper is considered to be a mutation of Brongniart's *Annularia longifolia*; it has wider leaves and longer internodes than the typical forms of the Coal-measures.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 27th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The President announced that the Foreign Secretary had, on behalf of the Officers and Council, addressed a letter of congratulation to Commendatore Prof. Arturo Issel, For. Corr. G. S., on the occasion of the fortieth anniversary of his professorate in Genoa University.

The following communications were read:—

1. "Interference Phenomena in the Alps." By Mrs. Maria M. Ogilvie Gordon, D.Sc., Ph.D., F.L.S. (Communicated by Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., P.G.S.)

In former papers[1] the authoress pointed out that, while the leading axis of the Alpine mountain system extended in an east and west direction, and it was generally accepted by Alpine geologists that Alpine areas had endured horizontal compressive stresses in a north-and-south direction, her own studies of Alpine geology had led her to the conclusion that there had also been cross deformation throughout the whole region, including both plicational and overthrust effects; and that this cross deformation had been induced in relation to horizontal pressures which had acted from the Hungarian Basin westward over Alpine areas. In a quite similar way, radially directed horizontal pressures had acted round the northern, eastern, and southern periphery of the Hungarian Basin, and had originated the deformational systems of the Carpathian Mountains.

On the Alpine side of the Hungarian Basin, owing to the resisting character of the previously plicated rocks composing the Palæozoic Alpine chain, the ancient chain had been broken up by the east-and-west compression into a series of cross segments or fault blocks, and there had been a general westward crush of the series. The leading cross segments named by the authoress were—(1) the Western Alps, (2) the Engadine, and (3) the Styrian Alps.[1 (2)] Overthrust effects had been produced not only at the western margins of the segments, but also in some cases at the eastern margins, e.g. notably in the Western Alps and at the Judicarian Fault in the Eastern Alps. Further, these same cross segments in the Central Alps had been, from their first initiation, interrupted on the north and south by ancient leading east-and-west faults, in relation to which sagging or downthrow movements took place towards the Central Alpine band, and overthrust movements occurred in opposite directions.

The present paper, so far as it deals with the general structure of the Alps, was completed in April, 1905; but, acting on the advice of Sir Archibald Geikie, the authoress has since endeavoured to strengthen her line of argument by taking as a type the series of structural changes undergone in the largely igneous mountain-massive of Bufaure in the Dolomites, and elucidating the successive phases from the point of view of historical geology.

After describing in detail the geology of the Bufaure Massive, the authoress discusses the structural relation of the Western Alps and the Engadine to one another and to the whole mountain system. From the particular arrangement of overthrusts, as well as from the distribution of the igneous intrusions in the Western Alps and in the Engadine, the authoress concludes that these were areas where

[1] M. M. Ogilvie Gordon: (1) "Torsion-Structure in the Alps," *Nature*, September 7th, 1899, vol. lx, pp. 443–446; (2) "The Crust-Basins of Southern Europe," Seventh International Geographical Congress, Berlin, 1899 (Proceedings of the Congress, part ii, pp. 167–180, pl. vii); and (3) "The Origin of Land-Forms through Crust-Torsion," Geogr. Journ., vol. xvi (1900), pp. 457–469.

leading cross faults intersected the east-and-west Central Alpine band, and shows how the coalescence of these cross faults with E.N.E.–W.S.W. faults on the north side and W.N.W.–E.S.E. faults on the south side defined two leading fault curves, the one passing through the Engadine and continuing in the Dalmatian Alps, the other passing through the Western Alps and continuing in the Apennines. These strike curves are essentially peripheral to the western side of the Hungarian Basin.

The cross segment comprising the Rhine-Ticino district between the Western Alps and the Engadine is, according to the authoress's interpretation, anticlinal in character, segments having been downthrown from it both towards the west and towards the east, and overthrust masses having crept eastward and south-eastward from the Western Alps, and westward from the Engadine.

The authoress then discusses the relation of the French Jura Mountains to the Alpine System, pointing out that the Swiss-French Plain flanking the Western Alps presents the same essential features of structure, in relation to the Western Alps on its east side and the French Jura Mountains on its west, as those that she has elucidated for the Rhine-Ticino cross segment. She consequently interprets the strike-curve round the west formed by the Jura Mountains and the ranges of Dauphiné as the outermost peripheral plicational system in the Alps, showing that the whole region between the Hungarian Basin and the ancient mountain groups of Central France has been under the influence of the westward thrust.

The general principle of structure treated of above—namely, the sagging of crust-blocks by means of normal faults towards bands or localities of crust-weakness or subsidence, and the reverse or overthrust movements which may take place from within these bands or localities—is that which the authoress demonstrated in the Dolomite Massives in 1893, and has ever since advocated as a leading principle in the interpretation of Alpine structures, the important consideration being that where, as in the Alps, the principle is applicable in relation to two intersecting axes of deformation, the phenomena produced must necessarily be of the nature of 'interference phenomena.'

A leading feature of the paper is the evidence that it affords of differential rates of movement in different parts of a thrust-mass, or fault-block undergoing horizontal displacement, both in respect of the laterally adjacent parts of a thrust-mass and also of the subjacent layers. The writer's maps and sections show that the actual deformations which characterize a thrust-mass have a different direction of strike on either side of an axial band of maximum horizontal displacement; for example, if the horizontal movement of a thrust-mass is westward, the deformational phenomena (faults, folds, etc.) in the western front of the thrust-mass curve on the north side towards some S.W.–N.E. or W.S.W.–E.N.E. direction, and on the south side towards some N.W.–S.E. or W.N.W.–E.S.E. direction. The authoress interprets these observations on the basis of the deflection of the general movement of the thrust-mass by the strains set up between the axial region of maximum horizontal displacement and the lateral regions where from any cause the horizontal displacement is less.

Another feature which may be mentioned is her description of several examples in the Dolomites where there had apparently been a local reversal of the regional westward movement, and her reference to the familiar examples of eastward overthrusts in the Judicarian district, and on the eastern and south-eastern front of the grander mountain massives of the Swiss and French-Italian Alps. While each individual case demands special examination, she indicates an explanation that satisfies certain cases which she has examined. At localities where the base of the thrust-mass is open to inflows of igneous rock, the igneous material may ascend and be carried onward with the gliding mass, undergoing consolidation during the movement, and inducing contact changes in neighbouring rock material. After consolidation of such igneous inflows, they present resisting bodies within the thrust-mass, which, in the same way as any massive developments of hard sedimentary material, impede the advance of rock material in the same direction as before, and thus cause local deflections. The tendency is for the material of the thrust-mass to be strongly plicated and faulted as it is driven against any such resisting body, widening out in a direction roughly parallel with the resisting mass, and piling up the material in front to such an extent that local reversal of the direction of overlapping is produced.

2. "The Influence of Pressure and Porosity on the Motion of Sub-Surface Water." By William Ralph Baldwin-Wiseman, M.Sc., Assoc. M. Inst. C. E., F.G.S.

The author commences the paper with a brief historical summary of the researches which have been conducted since 1830 on the motion and behaviour of underground water, more especially dealing with the question of sub-surface flow and the delimitation of cones of depletion.

In the second part of the paper, in discussing the influence of the porosity of a rock, on the rate of flow of water through it, he describes in detail the variations in porosity which may occur in restricted areas of the same rock, due to superincumbent pressure, faulting, and the intrusion of dykes, illustrating the various points with data collected in the field. He also discusses and describes experiments on the rate of desiccation and soakage of various rocks.

He then describes a lengthy series of laboratory experiments, which he conducted with specially devised apparatus of his own design to afford a constant pressure and to eliminate all possible errors due to lateral flow, and in which he demonstrates that there is not a uniform relation between flow and pressure in various rocks over a considerable range of pressure, and discusses the various phenomena which were manifested.

In the third portion of the paper he describes the various attempts at determining the range of the cone of depletion in various strata, and then proceeds to outline a method based upon an experimental determination of the variation of internal pressure in a rock mass when charged with water and subjected to a considerable difference of